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Volume I- Project Information Summary

submitted to the

Department of Energy

by the

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of

o, California

and Water Heating

o International Airport

-01-4200

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Volume I - Project Information Summary

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Department of Energy

by the

Airports Commission

of the city and county of

San Francisco, California

for

Solar Space and Water Heating

at

San Francisco International Airport

in response to

PON EG-78-N-01-4200

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PROJECT SUMMARY DATA

A. PROJECT PARTICIPANTS

1. PROPOSER

NAME: Airports Commission of The City and County of San Francisco

MAILING ADDRESS: San Francisco International Airport

San Francisco, CA 94128

2. BUILDING OWNER

NAME: Airports Commission of The City and County of San Francisco

MAILING ADDRESS: San Francisco International Airport

San Francisco, CA 94128

3. PROJECT LOCATION: San Francisco, CA

4. TYPE OF APPLICATION (Bldg. Use): Airport

5. NEW X RETROFIT

6. LAND STATUS: Owned (Option, Owned, Leased)

7. TYPE OF SOLAR SYSTEM

HEATING & COOLING	☐	HEATING, COOLING, HOT WATER	☐
COOLING	☐	COOLING, & HOT WATER	☐
HEATING	☐	HEATING & HOT WATER	☒

8. CONTACT FOR ADDITIONAL INFORMATION

	BUSINESS	TECHNICAL
NAME	Robert G. Lee, Deputy Director and Chief Engineer	Dale Sartor
ADDRESS	Airports Commission San Francisco Internat'l Airport San Francisco, CA 94128	Interactive Resources, Inc. 117 Park Place Point Richmond, CA 94801
TEL. NO.	(415) 876-2224	(415) 236-7435

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B. BUILDING SUMMARY

1. BUILDING FLOOR AREA 200,000 SQ. FT.

2. SOLAR CONDITIONED AREA 175,000 SQ. FT.

3. ANNUAL DESIGN LOAD (10^6 BTUs)

HEATING 4429 COOLING N/A HOT WATER 760 TOTAL 5189

4. PRESENT OR PROJECTED CONVENTIONAL (WITHOUT SOLAR) ENERGY COSTS/YR* $ 17,798

5. BACKUP ENERGY SYSTEM (Type and Commercial ID)

HEATING gas/oil Interruptable natural gas. Probable 50/50 gas/oil use.

COOLING N/A

HOT WATER gas/oil heating from central plant.

C. SOLAR ENERGY SYSTEM

• SOLAR COLLECTOR (BASELINE)

1. TYPE:
- [X] LIQUID
- [ ] AIR
- [X] FLAT PLATE
- [ ] EVACUATED TUBE
- [ ] OTHER (Specify)

2. COMMERCIAL ID Solar Energy Products, Inc. CU30

3. TOTAL COLLECTOR AREA** 7961 FT.^{2}

4. EFFECTIVE COLLECTOR AREA 7,200 FT.^{2}

5. ABSORBER COATING Nextel

6. NO. OF COVER PLATES 1

7. ABSORBER MATERIAL Copper flow tubes mechanically expanded into aluminum wings.

8. TILT ANGLE 37°

9. AZIMUTH 15° West of Due South (State in degrees East or West of due South)

*Based on July 1977 Rates

**Total Collector Area refers to gross solar panel size. Effective collector area refers to the absorber aperture area.

- ENERGY TRANSPORT

10. FLOW RATE 180 GPM N/A CFM

FOR LIQUID ENERGY TRANSPORT STATE:

11. TYPE Water

12. COMPOSITION N/A

- ENERGY STORAGE

13. TYPE: Tank(s), Box(s), None, etc. Tank

14. NUMBER HOT 2 15. NUMBER COLD 0 16. TOTAL 2

17. GROSS CAPACITY: HOT 12,900 gal (GAL); (CU FT)

COLD N/A (GAL); (CU FT)

18. METHOD OF POTABLE WATER PROTECTION N/A

- SOLAR HEATING SUBSYSTEM (INCLUDING AUXILIARY)

19. TYPE Heat exchanger with water loop going to hot deck of a variable air volume system. 20. CAPACITY 3,221,000 BTUH

- SOLAR COOLING SUBSYSTEM (INCLUDING AUXILIARY)

21. TYPE N/A 22. CAPACITY N/A BTUH

D. CLIMATIC DATA

1. LATITUDE 37° 37' 2. ALTITUDE 8 FT.

3. HEATING DEGREE DAYS 3042 /YR. 4.* COOLING DEGREE DAYS 108 /YR.

5. AVERAGE TEMP. WINTER (January) SUMMER (July)

48.3 °F 62.5 °F

*Use 65°F reference for heating and 75°F reference for cooling.

		WINTER (January)	SUMMER (July)
6.	DAILY AVERAGE INSOLATION (HORIZONTAL)	710 BTU/FT^2	2193 BTU/FT^2

7. MEAN CLOUD COVER 5 tenths 8. SOURCE OF DATA California Solar Data Manual, January, 1977.

9. AVERAGE ANNUAL TOTAL INSOLATION, UPON COLLECTOR SURFACE, BTU/FT^2- YR

596,525 BTU/FT^2-YR

10. STATE BASIS FOR CALCULATION FCHART Computer Simulation

E. ENERGY UTILIZATION

1. ANNUAL UNIT SOLAR ENERGY COLLECTED, BTU/YR - FT^2 249,305 BTU/FT^2-YR
Useful energy

2. TOTAL SOLAR ENERGY COLLECTED, BTU/ YR 1795 x 10^6 BTU/YR
Useful energy

		ANNUAL SOLAR USAGE (10^6 BTU)	ANNUAL ENERGY CONSUMPTION (10^6 BTU)	AUXILIARY ENERGY CONSUMED (10^6 BTU)
3.	HEATING DEMAND SATISFACTION	1532	4429	2896
4.	HOT WATER DEMAND SATISFACTION	262	760	497
5.	COOLING DEMAND SATISFACTION	N/A	N/A	N/A
6.	TOTAL DEMAND SATISFACTION	1795	5189	3394

7. TOTAL YEARLY COST OF OPERATING SOLAR SYSTEMS $ 18,111
(FROM APP. D, EXHIBIT 3, ITEM A-10)

F. FUNDING AND COST-SHARING SUMMARY (FOR RETROFIT, FILL IN ITEM F.3 ONLY)

1. TOTAL CONVENTIONAL BUILDING COST (for new buildings) $ 19,300,000

2. TOTAL BUILDING COST WITH SOLAR ENERGY SYSTEM (for new buildings) $ 19,947,000

3. SOLAR SYSTEM COST DIFFERENTIAL (for new or retrofit bldgs.) $ 647,000
(Line 2 minus Line 1 should equal item E, from Appendix D, Exhibit 2)

4. COST SHARING PROVISIONS

PROPOSER		ERDA	
$ 161,750	25 %	$ 485,250	75 %

(Proposed Cost sharing of Solar System Cost Differential stated in Line 3.)

5. SOLAR SYSTEM COST EFFECTIVENESS:

a. ANNUAL ENERGY COST WITH CONVENTIONAL SYSTEM (APP. D, EXHIBIT 3, ITEM B-3) $ 17,798

b. ANNUAL ENERGY AND OPERATING COST WITH SOLAR SYSTEM (APP. D, EXHIBIT 3, ITEM A-10) $ 18,111

c. ANNUAL SAVINGS (Line a minus Line b) $ - 313

6. FIXED COST TO ANNUAL SAVINGS RATIO Negative number. See note below.
(Line 3, Solar Systems Cost Differential; divided by Line 5c, Annual Savings)

Note:

December 1977 fuel rates produce this negative number. With a 15% yearly increase in gas/oil prices, next year's savings (5c) will be 764 and the fixed cost to savings ratio (6) will be 846. System start-up is expected in early 1981.

*Based on December 1977 Utility rates

Volume II- Technical Proposal

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of the city and county of

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Volume II

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Volume II

TECHNICAL PROPOSAL

1. Building and System Summary

1.1 Existing Facilities. San Francisco International Airport passenger facilities presently consist of the Central and South Terminals with their respective piers and boarding areas (see Figure 2.1).

1.2 Facilities Under Construction. A new North Terminal and Piers H and I are under construction and scheduled for completion in mid-1978. Construction has also begun on expanding the garage.

1.3 Future Facilities. Expansion of the Airport will continue with the Modernization and Replacement Phase as shown in Figure 2.2. This work includes:

Stage 1: South Terminal West Addition
Boarding Area G and Connector

Stage 2: Central Terminal Modifications
New Piers E and F

Stage 3: South Terminal Modifications
New Pier D
Renovation of Piers B and C

1.4 Solar Energy Feasibility Study. On June 15, 1976, the Airports Commission of the City and County of San Francisco adopted a resolution directing the Director of Airports and staff to

> ....investigate and make such studies as necessary on the feasibility, application and use of solar energy at San Francisco International Airport.

The Airports Commission conceived this study as a logical extension of an existing energy conservation operating and maintenance policy.

The study was completed in September 1977, and concluded that the use of solar energy at the Airport was technically feasible and cost-effective. The solar system proposed herein is the pilot project which, if successful, will lead to additional solar applications throughout the Airport complex.

1.5 Proposed Project. In November 1977, San Francisco voters approved a $90 million bond issue for construction of the Airport's Modernization and

Replacement Phase. The proposed solar project consists of space and domestic water heating of the new South Terminal West Addition, and its connector to Rotunda A, expected to begin construction in late 1978.

1.6 Building Function. The South Terminal West Addition project provides critically needed facilities for U.S. Customs, Immigration, Health, Agriculture, access to the garage and improved public amenities. It includes replacement facilities for the inspection of international passengers and baggages and a connector, with a separate international arrival corridor between the new facility and the International Rotunda A, as well as minor apron work, a pedestrian bridge with moving walks and finishing of the existing tunnel to provide public access to and from the parking garage addition now under construction.

The existing baggage handling facility, customs area, and federal inspection facilities in the South Terminal are grossly inadequate to handle even one large aircraft. A wait of up to two hours before final clearance after landing is not uncommon. These facilities will expedite the processing of international passengers, relieve present restrictions on the size and number of flights which can be processed simultaneously and provide the required public access to the parking garage.

1.7 Proposed Solar System. The proposed solar system involves the construction of 7,200 square feet of flat plate collectors on the roof of the new South Terminal West Addition. These collectors are expected to provide approximately 34 per cent of the required space heating and domestic hot water heating load of the West Addition and new connector to Rotunda A, both of which will be conditioned by the same mechanical system. Rotunda A has its own separate mechnaical system and is not a part of this solar project.

1.8 Solar System Performance Calculations. Solar performance calculations were performed using the design computer program FCHART developed by the University of Wisconsin. FCHART is an interactive computer program used to calculate the thermal performance of solar space heating and domestic hot water heating systems. The general design procedure was developed at the University of Wisconsin from a simulation model capable of estimating the long-term thermal performance of solar heating systems from the system design parameters, heating loads and weather data.

1.9 Economic Optimization. FCHART computer simulations were run for a range of collector areas in order to find the collector size that would maximize the BTU's per dollar invested (see Appendix A).

Using a solar system with 7200 square feet of collector area and a system cost of $647,000, an FCHART solar simulation and life-cycle economic analysis was run. First year fuel costs were inflated to account for the system start-up in early 1981. The FCHART life-cycle analysis shows a 6.1 per cent internal rate of return over 30 years (see Appendix A).

A sensitivity analysis of the solar system was run. System cost, fuel price increase, yearly maintenance costs, value of money and term of economic analysis were all varied to investigate the relative influence of each parameter on life-cycle value. The analysis showed the overwhelming influence of time on the economic value of the system, while the other parameters, including initial cost, showed a relatively small impact on long-term value. This suggests that extra initial costs which add to the life of the system are well spent. In addition, a system that can survive the inevitable remodeling the Airport experiences would realize much greater returns.

1.10 Backup Fuel. The Airports Commission and its staff are acutely aware of the rising costs of conventional fuel. This is especially evident because of their increasing use of oil over natural gas.

In 1976, the Airport operated on a 90/10 per cent gas/oil ratio. However, Pacific Gas and Electric Company has given notice that it will not be able to guarantee supply of the same amount of natural gas in the future. The exact ratio will depend primarily on the availability of the cheaper natural gas, but it is expected that for the next 20 years, the Airport will operate on an approximately 50/50 gas/oil ratio.

2. SUBSYSTEM PERFORMANCE/TECHNICAL DATA

A. COLLECTOR (BASELINE)

COMMERCIAL BRAND NAME*: Solar Energy Products, Inc. MODEL: CU30

TESTED BY AND METHOD: NBSIR.74635, ASHRAE 93-P and ASHRAE 93-77 by Desert Sunshine Exposure Tests, Inc., Phoenix, Arizona

EST. DELIVERY TIME: 60 days from receipt of order **

(See manufacturer's quote in Volume IV.)

1. TYPE OF COLLECTOR ☒ LIQUID ☐ AIR

   a. FLAT PLATE: X

   b. TUBULAR: _____ EVACUATED: _____ NON-EVACUATED _____

   c. CONCENTRATOR: TRACKING: _____ NON-TRACKING: _____

   TRACKING MODE: _____

   CONCENTRATION RATIO: _____ :1 TYPE: _____

   d. OTHER: DESCRIBE IN DETAIL This is a baseline collector. Competitive procurement is required. See Section 6.2 for minimum standards of alternate collectors.

2. TRANSPARENT COVER

   a. NUMBER OF COVERS: 1

   b. MATERIALS: OUTER: Water White Glass INNER: N/A

   c. THICKNESS: OUTER: 3/16 (IN) INNER: N/A (IN)

   d. SOLAR SPECTRUM TRANSMISSIVITY: OUTER: 91% INNER: N/A

   e. WEIGHT: OUTER: 2.85 LBS/FT^2 INNER: N/A LBS/FT^2

*Baseline used for proposal (In the case of required competitive procurement use a typical example for purposes of this section)

** Include an affadavit from collector manufacturer indicating that the quoted price of collectors proposed is valid for a period of 180 days following the closing date of this PON (not applicable for planned competitive procurements).

SUBSYSTEM PERFORMANCE/TECHNICAL DATA (Continued)

3. ABSORBER PLATE

a. ABSORPTIVE COATING

1. MATERIALS

a. TYPE: Flat Black

b. ALLOY: Nextel

2. SOLAR SPECTRUM ABSORPTIVITY: 0.98 %

3. INFRARED EMISSIVITY: 0.89 %

b. BASE PLATE

1. MATERIALS

a. TYPE: Aluminum

b. COMMERCIAL IDENTIFICATION: N/A

c. FLUID PASSAGES

1. MATERIALS

a. TYPE: Copper

b. COMMERCIAL IDENTIFICATION: Type L

d. BONDING MATERIALS BETWEEN BASE PLATE AND FLUID PASSAGES

1. TYPE (BRAZED, SOLDERED, ADHESIVE, MECHANICAL, ETC.) Mechanical

2. COMPOSITION: N/A

3. COMMERCIAL IDENTIFICATION: N/A

4. OTHER Copper flow tubes mechanically expanded into extruded aluminum wings.

4. INSULATION MATERIAL

a. TYPE: Rigid sandwich with aluminum foil faces.

b. COMPOSITION: Isocyanurate

c. COMMERCIAL IDENTIFICATION: Celotex Technifoam

d. THICKNESS: BACK 1-1/8 IN. SIDES 1/2 IN.

e. R FACTOR: BACK 12.5 SIDES 5.56

SUBSYSTEM PERFORMANCE/TECHNICAL DATA (Continued)

5. OUTER ENCLOSURE OR SHELL MATERIALS

a. TYPE: SIDES Aluminum Extrusion BACK Aluminum sheet

b. THICKNESS: SIDES 0.25 in. BACK 0.032 in.

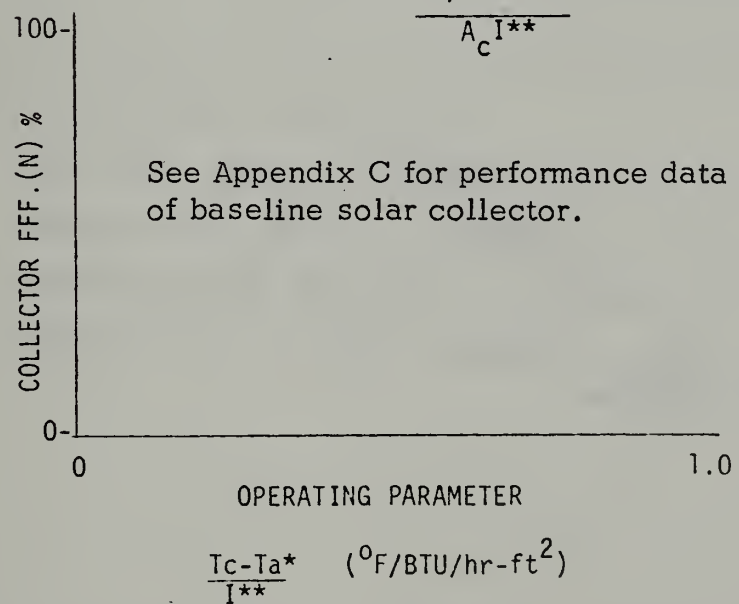
c. COMMERCIAL IDENTIFICATION: SIDES Alloy #6063-T5 BACK N/A

6. COMPOSITE COLLECTOR (SEE APPENDIX C)

Performance Data -- Provide test or Performance Analysis Data along with information detailing the conditions under which the data were generated. Active systems require that test results be submitted rating the solar collector in accordance with the NBS "Method of Testing for Rating Solar Collectors Based on Thermal Performance,"(Document NBSIR 74-365)[1], the ASHRAE "Methods of Testing to Determine the Thermal Performance of Solar Collectors" (ASHRAE Standard 93-77)[2], or through other procedures which will provide similar performance information, as determined by DOE.

PROVIDE A GRAPH OF COLLECTOR EFFICIENCY (n) VERSUS THE PARAMETER $\frac{Tc-Ta^*}{I}$

where $n=\frac{MC_p(To-Ti)}{A_c I^{**}}$



1 Available from DOE, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

2 Available from ASHRAE Inc., 345 East 17th St., New York, N.Y., 10017, $4.00 Member, $8.00 Non-Member, plus $0.35 shipping.

To = Collector transport media outlet temperature (^{o}F)
Ti = Collector transport media inlet temperature (^{o}F)
*Tc = 1/2 (To + Ti)
Ta = Ambient Temperature (^{o}F)
**I = Solar Insolation on the Collector Plane (BTU/HR-FT^2)
M = Transport Media mass flowrate (lb/hr.)
Cp = Specific heat of transport media (BTU/LB^{o}F)
***Ac = Area of Collector (ft^2)

*The ASHRAE procedure uses Ti=Tinlet rather than Tc=average of inlet and outlet temperatures. Either method is acceptable but state which is being used.
**For tracking collectors this value should be only the beam or direct component for the solar radiation.
***Define Ac as gross or net;Ac is gross collector area for ASHRAE 93-77, net aperture area for NBSIR 74-365.

7. MAXIMUM EXPECTED TEMPERATURE UNDER NO FLOW CONDITIONS 275^{o}F

8. DISCUSS PROVISIONS FOR PROTECTING COLLECTOR UNDER NO FLOW CONDITIONS

There is no damage to collectors at stagnation temperatures.

9. COLLECTOR DIMENSIONAL CHARACTERISTICS

a. GROSS AREA 33.17 FT^2/PANEL

b. APERTURE AREA 29.92 FT^2/PANEL

c. WEIGHTS OF FILLED COLLECTOR 9.93 LBS/FT^2 (Aperture)

d. ESTIMATED WEIGHT OF SUPPORT STRUCTURE 26 LBS/FT^2 (Aperture)
includes concrete curbs

3. SOLAR STORAGE*

1. TYPE (TANK, ROCK BED, ETC.) Tank

2. MATERIALS

a. TYPE: Concrete cistern

b. FINISHES OR COATINGS: INTERIOR T.B.D. EXTERIOR

c. COMMERCIAL IDENTIFICATION: N/A

d. INSULATION (TYPE/THICKNESS): Flame retardant urethane

e. R FACTOR: 30 $\frac{HR\text{-}FT^2\text{-}^oF}{BTU}$

3. PHYSICAL DIMENSIONS: Integrated with building structure

a. HEIGHT: 12

b. WIDTH: 16

c. LENGTH: 16

d. DIAMETER:

e. DEPTH (if buried)

f. WATER TABLE DEPTH (if buried)

4. OPERATING TEMPERATURE RANGE: 32° - 210°F. ^oF

5. OPERATING PRESSURE RANGE: Tank vented to atmosphere PSI

6. BURST PRESSURE OR ASME RATING: N/A PSI

4. HEATING SUBSYSTEM

1. SOLAR

a. TYPE: Variable volume air system - fin coil FIN COIL, RADIATOR, ETC.

b. COMMERCIAL UNIT

1. TYPE: To be determined in final design

2. SIZE & BTU RATING (CAPACITY): N/A

3. COMMERCIAL IDENTIFICATION: N/A

2. CONVENTIONAL

a. TYPE Interruptable gas, and oil GAS, OIL, ELECTRIC, ETC.

*If a phase change system, list type, heat capacity, and temperature of phase change.

b. COMMERCIAL UNIT

1. SIZE: To be determined in final design

2. COMMERCIAL IDENTIFICATION: N/A

c. COEFFICIENT OF PERFORMANCE: IF APPLICABLE, THE COP VERSUS PERTINENT OPERATING CONDITIONS (AMBIENT TEMPERATURE, ETC.)

d. TOTAL HEATING CAPACITY: 3,221,000 BTU

D. HOT WATER SUBSYSTEM

1. SOLAR UNIT

a. TYPE: heat exchanger

b. SIZE: 300,000 BTU/HR

c. COMMERCIAL IDENTIFICATION: Bell & Gossett

d. HEAT EXCHANGER TYPE:* Two pass shell and tube

2. CONVENTIONAL UNIT

a. TYPE: Interruptable gas, and oil (GAS, OIL, ELEC. STEAM, ETC

b. SIZE: To be determined in final design VOL. OR BTU

c. COMMERCIAL IDENTIFICATION: To be determined

d. CODE & SAFETY STD. CERTIFIED UNDER: To be determined

E. COOLING SUBSYSTEM (NONE)

1. SOLAR

a. TYPE: N/A

b. SIZE: N/A TONS

*Proposers are referred to the IPC for measures necessary to isolate potable and non-potable water systems.

c. COMMERCIAL UNIT IDENTIFICATION: N/A

d. COP VS. CHILLED AND CONDENSING WATER TEMPERATURE TABLES: N/A

2. CONVENTIONAL

a. TYPE: Centrifugal RECIP, CENTRIFUGAL, ABSORPTION

b. COMMERICAL UNIT

1. TYPE: Two 3000 ton chillers located in a central
2. SIZE: plant supplying chilled water to a primary
3. IDENTIFICATION: loop that runs around the outside of the airport garage.
4. COP VS. TEMPERATURE TABLE:

F. TRANSPORT BETWEEN SUBSYSTEMS

1. PIPING DETAILS	COLLECTOR TO STORAGE	STORAGE TO LOAD
a. INNER DIAMETER:	4.000 in	6.000 in
b. OUTER DIAMETER:	4.125 in	6.125 in
c. LENGTH OF RUN TOTAL:	450 ft	100 ft
d. MATERIALS:	Type L copper	Type L copper
2. PIPING INSULATION		
a. TYPE:	Glass fiber	Glass fiber
b. THICKNESS:	1 in	1 in
c. 'U' FACTOR:	0.17 BTU/HR-SF-°F	0.18 BTU/HR-SF-°F
3. TRANSPORT MEDIA		
a. TYPE:	Water	Water
b. ADDITIVES		
1. COMMERCIAL IDENTIFICATION:	None	None
2. TYPE:	N/A	N/A
c. QUANTITIES OF FLUID IN SUBSYSTEM		
1. FLUID:	N/A	N/A %
2. ADDITIVE:	N/A	N/A %

SUBSYSTEM PERFORMANCE/TECHNICAL DATA (Continued)

	COLLECTOR TO STORAGE	STORAGE TO LOAD
3. pH:		
4. ION CONTENT:	Conductivity = 43.3 mhos/cm 25°C	Same
5. MINERAL CONTENT:	Alkalinity = 16.0 MG/L Hardness = 20.3 MG/L	Same Same
6. DURABILITY (SERVICE LIFE):	Indefinite MONTHS	Indefinite MONTHS
d. SPECIFIC HEAT:	1 BTU/# °F.	1 BTU/# °F.
e. FLOW RATE (LIQUID):	180 GPM	330 GPM
FLOW RATE (AIR):	N/A SFCM	N/A GPM
f. SPECIFY PRESSURE DROP BETWEEN COMPONENTS:	35 PSI	40 PSI
4. HEAT EXCHANGERS		
a. TYPE (CROSS OR COUNTERFLOW):	None	Two pass shell & tube
b. FLOWRATE:	N/A GPM	330 GPM
c. OVERALL UA FACTOR:	N/A BTU/OF	322,100 BTU/HR,°F.

5. PROVIDE FLOW DIAGRAM FOR PROPOSED SOLAR ENERGY SYSTEM, GIVING SUBSYSTEM COMPONENTS LOCATION AND IDENTIFICATION AND FLOW DIRECTIONS. (See Appendix B.)

G. CONTROL SYSTEM (See Section 10.)

SHOW FOR EACH MODE OF OPERATION A DESCRIPTION OF COMPONENTS AND VERBAL DESCRIPTION OF CONTROL SYSTEM; INTEGRATED SOLAR AND CONVENTIONAL SYSTEM(S)' OPERATIONS.

PROVIDE A SCHEMATIC OF CONTROL SYSTEM (MAY BE INTEGRATED WITH F.5.

(See Appendix B for plans and drawings.)

SYSTEM PERFORMANCE/TECHNICAL DATA

ELECTRICAL POWER

1. OPERATING REQUIREMENTS

a. THE ELECTRICAL ENERGY REQUIRED TO DRIVE THE SOLAR COLLECTION PORTION OF THE SYSTEM IS 11.2 kw

1. PUMPS 11.10 kw FUNCTION Solar circulation pump
2. FANS none kw FUNCTION N/A
3. CONTROLS 0.1 kw FUNCTION Differential controller and pump starter
4. OTHER none kw FUNCTION N/A

b. THE ELECTRICAL ENERGY REQUIRED TO DRIVE THE STORAGE TO LOAD PORTION OF THE SYSTEM IS 14.9 kw

1. PUMPS 14.8 kw FUNCTION Pump to solar heat exchanger
2. FANS none kw FUNCTION N/A
3. CONTROLS 0.1 kw FUNCTION Differential controller and pump starter
4. OTHER none kw FUNCTION N/A

2. DESIGN LOAD DATA:

INCLUDE LOAD DUE TO VENTILATION REQUIREMENTS

BUILDING LOAD TABLE

MONTH	HEATING (BTU)	HOT WATER (BTU)	COOLING (BTU)
January	956,640,000	64,540,000	N/A
February	628,090,000	58,290,000	
March	557,230,000	64,540,000	
April	392,960,000	62,460,000	
May	202,920,000	64,540,000	
June	106,290,000	62,460,000	
July	74,080,000	64,540,000	
August	67,640,000	64,540,000	
September	51,540,000	62,460,000	
October	177,150,000	64,540,000	
November	460,710,000	62,460,000	
December	753,710,000	64,540,000	
YEARLY TOTAL	4,428,980,000	759,910,000	
DESIGN PEAK (BTUH)	3,221,000	300,000	

SOLAR SYSTEM ARRAY PERFORMANCE (See FCHART computer simulation, Appendix A)

COLLECTOR TYPE: Liquid Flat Plate LOCATION: San Francisco International Airport

ARRAY AREA: 7181 FT^2; LATITUDE: 37.5 °; TILT ANGLE FROM HORIZONTAL: 35 °; AZIMUTH: + 12 (+=West, 0=Due South, -=East)

LINE	DESCRIPTION	UNITS	MONTH											
			J	F	M	A	M	J	J	A	S	O	N	D
(1)	Number of days		31	28	31	30	31	30	31	31	30	31	30	31
(2)	Average Temp. - (Tamb)*	°F	48.3	51.2	53.0	55.3	58.3	61.6	62.5	63.0	64.1	61	55.3	49.7
(3)	Max Average Temp (Tmax)*	°F	55	59	61	64	67	70	71	72	74	70	63	57
(4)	Average Ambient (Ta)1/2 (2) + (3)	°F	51.7	55.1	57.0	59.7	62.7	65.8	66.8	67.5	69.1	65	59.2	53.4
(5)	Clearness Factor	-												
(6)	Average Collector Temp - (Tc) = 1/2(Tin+Tout)	°F				Not in FCHART output								
(7)	Collector Efficiency	-												
(8)	Average Monthly Insolation on Tilted Collector Surface	BTU/ft^2	25.4	26.6	39.4	43.7	43.9	44.2	45.3	44.3	40.9	33	21.7	22.5
(9)	Mean Cloud Cover*		6	6	6	5	5	4	4	4	3	4	5	6
(10)	Monthly Probable Insolation	BTU/ft^2												
(11)	Collected Energy (Qc)	Million BTU				Not in FCHART output								
(12)	Q Loss (Piping & Losses)	Million BTU												
(13)	Q Usable	Million BTU	119	149	210	209	187	149	128	122	112	158	138	107
(14)	Total Load Bld (Solar Conditioned)	Million BTU	1021	686	621	455	267	168	138	132	114	214	523	818
(15)	Auxiliary Energy Required	Million BTU	901	536	411	245	79	19	10	9	2	82	384	711
(16)	% Solar Contribution		11.7	21.8	33.9	46.0	70.2	88.6	92.8	92.9	98.5	65	26.5	13.1
(17)	Time of Collector Operation	Hours	74	67	74	120	124	144	148	148	168	111	90	74
(18)	Electric Power for Collection Subsystem	KWH	821	743	821	1332	1376	1596	1642	1642	1864	1232	999	821
(19)	Electric Power for Storage to Load Subsystem	KWH	1094	990	1094	1776	1834	2128	2189	2189	2485	1642	1332	1094
(20)	Total Solar System Electric Power	KWH	1915	1733	1915	3108	2410	3724	3831	3831	4349	2874	2331	1915

*Source of Data to be Specified: California Solar Data Manual.

3. Energy Conservation Considerations

The solar energy feasibility study at San Francisco International Airport focused not only on solar applications but alternate energy conservation measures which might be more economically attractive. Steps have already been taken to implement the most cost-effective of these energy conservation measures. Other options, which apply to new construction or require substantial capital investments, will receive further study as plans for the Modernization and Replacement Phase are finalized.

a. Lighting. Reducing the lighting load by increasing efficiency and reducing levels will save energy in two ways. First, by reducing the electricity used for lighting and, second, by reducing the heat associated with lighting and the corresponding cooling requirements. Wattage of both fluorescent and incandescent lamps will be reduced during normal relamping at little or no additional cost. Whenever ballasts are replaced, more efficient units will be substituted. Artificial lighting in the terminal lobbies and in the piers will be reduced or eliminated during daylight. For example, turning off half of the main lobby lights in the South Terminal for 10 hours per day will reduce the lighting levels about 10 to 15 per cent and will save close to 200,000 KWH per year, or over $5,000. Automatic switches controlled by photo cells will be installed to ensure adequate lighting levels and maximum utility savings. Lighting levels in certain areas can be reduced permanently. The potential annual energy savings due to conservation in lighting is 2.5 million KWH.

b. HVAC Controls. Improper calibration and operation of controls including leaking and frozen dampers can account for sizable energy inefficiencies. All controls will be carefully checked and calibrated. A thermostat strategy will be established to slightly expand the comfort range to save heating and cooling, i.e., heating at 65-68°F. and cooling at 78-80°F.

c. Static Pressure Losses. The air systems in the North Terminal, Piers H and I and Rotunda A have high velocity duct systems ranging from 6.5-inch to 11-inch static pressure losses as compared to 3.5-inch in the Central and South Terminals. Such high pressure systems are energy-intensive and can be improved by reducing the air quantity and/or reducing the mechanical losses through the air filters. A 10 per cent reduction in air quantity will reduce motor horsepower 35 per cent and will save over 2.7 million KWH annually. Removing a portion of the filters will increase maintenance and lower air quality but could save 1.8 million KWH per year due to reduction in static pressure.

d. Motors. Small motors being replaced or installed will be replaced with more efficient, longer life units at slightly higher costs.

e. Garage Exhaust. Supply fans in the new garage are controlled by carbon monoxide monitors. Exhaust fans can also be controlled in this fashion (currently they operate continuously). With the strong prevailing winds and cyclical nature of the garage traffic, automatic exhaust controls could save 50 per cent or 300,000 KWH per year.

f. Domestic Water Temperature. Domestic water temperature in the new North Terminal and Piers H and I is already set at 105°F. The water temperature in the existing terminals and piers will be reduced from 140°F. and future remodeling also be designed for 105°F. Lower water temperatures conserve energy by reducing heat loss and facilitate solar interface.

g. Water Use. Water conservation saves energy in pumping, treating (supply and waste) and heating for domestic hot water. Flow restrictors and other water-saving devices will be considered.

h. Ceiling fans. Thermostatically controlled, variable speed ceiling fans can save heating and cooling costs. At low speeds they cut heating requirements up to 30 per cent by minimizing temperature stratification (the difference between ceiling and floor temperatures). At higher speeds (increased air velocity) ceiling fans have a cooling effect. The greatest cooling loads occur at the airport when crowds of people gather at one gate. Fans will delay if not eliminate the need for air cooling by allowing the temperature to rise while maintaining human comfort levels.

i. Increase Thermal Mass. Instead of wasting internal heat generated by people, lights and machinery, and the heat from solar gain (by operating an energy-consuming air cooling system) thermal mass can be employed to absorb excess heat and store it for night time or later use. Increasing the thermal mass of a building with masonry, water or phase change materials will dampen or stabilize the effects of exterior and interior temperature fluctuations and will be considered in future construction.

j. Insulation. Generally, insulation is a good investment and should be increased in the roof, walls and floors (over unheated spaces); however, the optimum amount has yet to be determined. In certain areas, insulation may be counter-productive: the internal heat generation from people, lights and machinery may exceed the heat losses requiring air conditioning, even with cool outside temperatures. The optimum insulation will be determined with computer modeling of the airport through a typical year. The computer simulation accounts for all heat gains and losses and can be used to compare alternative architectural and mechanical strategies.

k. Outside Air Economizer. The existing HVAC systems in the Central and South Terminals including boarding areas have provisions for ventilating with outside air. The new North Terminal and piers have a limited fixed outside air intake. Often cool outside air circulating through the terminal could substitute for air conditioning; rarely is the airport's ambient temperature above the comfort range. Converting the North Terminal's mechanical system to a variable outside air intake dependent on the cooling load and outside temperature will save over four million KWH per year.

l. Ventilation. Natural ventilation has limited potential due to noise and air quality problems, but additional mechanical ventilation may be effective, especially in cooling the thermal mass of a passive solar system.

m. Program Start-Stop. The airport traffic is cyclical and energy can be saved by shutting off some of the 363 fans during low-load periods. A reduction of only one hour per day of operation (excluding garage vent motors) would save 1.3 million KWH per year.

n. Automatic Faucets. Automatic closing faucets will be used to save water and reduce the corresponding energy required for heating.

o. Flue Gas Heat Recovery. Commercially available economizer heating coils can be installed in the central boiler exhaust flues to capture waste heat for domestic water and/or space conditioning.

p. Insulating Glass. Insulating glass, like insulating walls, will save energy and increase comfort during the heating season; however, their overall effectiveness may be counter-productive where internal heat gains dominate heat losses and air conditioning is required. Again, computer modeling will be used to provide the optimum solution.

q. Automatic or Remote Peak Power Reduction. A system to automatically "shed" or turn off electrical demands on a pre-determined priority schedule will lower peak demand and utility cost. Presently the utility cost savings is small. However, utility pricing trends are clearly toward minimizing peak demands in order to reduce the need and subsequent capital expenditure for new power plants. A computerized load control system which could be programmed to turn off fans and other demands on a regular basis (at night, etc.) is a possibility for the future.

r. Conversion to Variable Air Volume System. All of the existing and new terminals under construction use the constant volume air system for cooling, heating and ventilation. The air quantities delivered are based

on block building peak loads for cooling. During much of the time, however, the building is operating at less than peak load and air quantities can be reduced without sacrificing comfort conditions. The reduction of air quantities during non-peak conditions will save energy by saving motor horsepower with the use of proper variable volume control devices. This also saves energy in cooling a smaller quantity of supply air and reheating air at some perimeter zones.

3.2 Compliance with ASHRAE 90-75. The State of California recently adopted strict energy standards for new non-residential buildings. These standards are largely based on ASHRAE 90-75 and compliance is required.

3.3 Target Energy Budget. The target budget for all energy use is 159,000 BTU/6SF/YR and is based on requirements of the State of California Title 24 Non-Residential Energy Standards. To meet this budget, electrical use is converted to BTU's and multiplied by three to account for generation and transmission inefficiencies.

3.4 Heat Load Calculations. The heating load for the proposed building was determined using the Pacific Gas and Electric Company procedure for calculating the equivalent full load operating hours. This procedure is more accurate than a degree day approach since it takes into account internal heat gains and building use patterns. Although it is not as accurate as a computer simulation, it provides more than the necessary precision to interface well with an FCHART solar simulation.

During final design, energy consumption of the proposed building will be modeled using the newly developed CAL/ERDA computer program. This will enable the designers to investigate the relative influence of various energy conservation strategies, to aid in the final sizing of conventional mechanical systems and to show compliance with the State energy code.

4. Compliance with Interim Performance Criteria

The proposed solar system complies with the "Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings". There are no known deviations.

5. Control of Design Changes

The Airports Commission of the City and County of San Francisco will exercise management and fiscal control over the project utilizing existing in-house accounting procedures.

Standard building contract management practices are to be followed. Design changes within the general scope of the work may be requested by any of the project contractors, endorsed or initiated by the professional consultants and submitted to the contracting officer for approval. All changes or deviations will be permanently recorded on a master set of as-built drawings and specifications at completion of the project.

6. Description of Solar Collectors

6.1 Baseline Collector. The Solar Energy Products, Inc., CU30 single-glazed, flat plate collector with water white glass was chosen as a baseline collector for the following reasons:

a. Long life (30 years).
b. All-copper flow tubes, compatibility with water.
c. Compatibility with stagnation temperatures.
d. High structural integrity.
e. High efficiency, excellent heat transfer properties.
f. Cost per unit of energy delivered.
g. Mounting flexibility.
h. Ease of maintenance.
i. Five-year guarantee.
j. Compliance with Interim Performance Standards (see Appendix D for catalog cuts).

6.2 Alternate Collectors. The proposed project will be competitively bid. Bids substituting alternate collectors will be accepted provided the collectors meet the following criteria:

a. Flow passages are compatible with water.
b. The working pressure is 150 psi minimum.
c. They are able to withstand stagnation temperatures without significant damage to their thermal performance.
d. All glazing is tempered glass.
e. They are designed to withstand wind loads up to 130 mph.
f. Internal joints are brazed.
g. They are fully drainable.
h. They meet the Interim Performance Criteria.
i. Their thermal performance has been tested in accordance with NBSIR 74-365 or ASHRAE Standard 93-77 test guidelines by an independent testing laboratory.
j. They carry a five-year warranty as outlined in the PON.

k. Collectors with lower efficiencies (lower y-axis intercepts and/or steeper slopes) than the Solar Energy Products, Inc., collector may be used provided the total collector area is increased to match the yearly system performance with the baseline collector. Likewise, the total collector area may be reduced if collectors of greater efficiency than the baseline collector are used provided the yearly system performance meets or exceeds that with the baseline collector. The method of comparison will be with the FCHART computer simulation program.

7. Acceptance Test Plan

Since the design is based on prescriptive rather than performance specifications, the only testing will be for operational functioning of the system's components and controls unless otherwise specified by DOE.

The prescriptive tests will include the following:

7.1 Pressure Test. All appropriate plumbing shall be pressure tested to 125 psi. All joints shall be examined and if leaks are found the system shall be drained, the leaks repaired and the system re-tested. The test pressure shall be maintained for at least four hours. Any component incapable of withstanding the test pressure shall be isolated or removed during the test.

7.2 Pump Amperage. The amperage input to each pump shall be measured and noted. The input shall be checked not to exceed the normal operating current ranges specified by the manufacturer.

7.3 Suction and Discharge Pressure. The suction and discharge pressure at each pump shall be measured. The pumps shall be set at their design flow rates.

7.4 Flow Rates. Where flow meters are installed they shall be calibrated and verification made as to the proper flow.

7.5 Differential Controllers. Adjustable control settings of the differential temperature controllers shall be set as specified. Operational check-out shall be as specified by the manufacturer. As a minimum, proper switching of the pump(s) and/or relays shall be checked. All control modes shall be experienced or simulated.

7.6 Freeze Control. Proper draining of the collector, manifolds and any other exposed plumbing shall be checked. No water shall be lost from the system at the time of drain down. If water rises to within 2" of the storage tank overflow, the float valve (automatic fill) shall be adjusted to decrease the tank's water level. Draining shall take no longer than 30 minutes.

7.7 Automatic Valves. All automatic motor and/or solenoid valves shall be tested in accordance with manufacturers' recommendations. As a minimum functional standard, valves must automatically open and close. Where valves are controlled by temperatures, proper functioning shall be checked at the desired temperature (range). This may require artificial heat or cold to simulate a required condition for testing. Tempering and/or mixing valves shall be checked for proper settings and function.

7.8 Other Control Devices. All other control devices shall be checked under all applicable operational modes for proper functioning.

7.9 Bypass. It shall be demonstrated that the entire solar heating system can be disconnected and/or inoperational without affecting the satisfactory and normal operation of the conventional backup system.

7.10 Servicing. All normal servicing procedures shall be performed or simulated during the acceptance test. If a task is impossible or difficult to complete due to inaccessibility or other problems, the condition shall be mitigated.

7.11 Operational Test. An operational test of the installed solar collection and space heating system shall be performed under actual service conditions during one complete sunny day. This test shall be run under the observation of the architect's and owner's personnel. Piping, equipment, controls and instrumentation must operate smoothly, efficiently, quietly and without excessive vibration. This test shall demonstrate successful operation of the system.

7.12 Certification of Testing. The contractor shall submit to the owner and architect certified copies of the final test readings with the following information:

a. Water flow rates at each metering station.
b. Suction and discharge pressures at each circulating pump.
c. Amperage input to each pump.
d. Checklist of tested items indicating conditions under which test was made.

The contractor shall certify that the system is water tight, protected from damage due to freezing, and is completely operational.

8. Construction Schedule

Feasibility Study	Completed
Schematic Design	Completed
DOE Review	1 February to 1 August 1978
Contract Negotiation	1 August to 1 September 1978
Design Development	1 September to 1 November 1978
Working Drawings	1 November to 1 February 1979
Design Review	1 February to 1 March 1979
Construction	1 March 1979 to 1 January 1981
Operational	1 January 1981

9. Solar Backup System Description

9.1 Central Plant. A new central plant is presently under construction. It is located at ground level of the new garage, diametrically opposite the Central Terminal.

Initially the central plant will have two 3,000-ton electrically-driven centrifugal chillers and three 25-million-BTUH-output, high-temperature hot water boilers. The ultimate capacity of the central plant will be 13,500 tons of cooling and 100 million BTUH of heating.

a. Heating. The high temperature heating hot water (HTHW) system is designed to furnish 400°F. primary supply hot water and 250°F. return water. The primary HTHW system is distributed in a loop around the perimeter of the entire garage. Water-to-water heat exchangers at various mechanical rooms provide secondary heating hot water at 200°F. to heating coils.

b. Cooling. (Solar cooling is not a part of the proposed project.) Chilled water is circulated through a primary loop which varies from 38°F. supply water temperature to 60°F. return water temperature. Secondary pumps at the various mechanical rooms provide secondary loop chilled water to cooling coils at 44°F. supply and 60°F. return water temperature. The primary chilled water loop runs adjacent to the primary HTHW system.

c. Backup Fuel. All boilers at the Airport are fired by natural gas and convert to No. 2 diesel oil when natural gas is unavailable. In 1976, the Airport operated on a 90/10 per cent gas/oil ratio. However, Pacific Gas and Electric Company has given notice that it will not be able to supply the same amount of natural gas in the future, and for 1978 and 1979 has allocated the amounts given in Table 1. The exact ratio will depend primarily on the availability of the cheaper natural gas. It is expected that for the next 20 years, the Airport will operate on an approximately 50/50 gas/oil ratio. Present fuel oil storage is 80,000 gallons with provisions to add an additional 80,000 gallons storage capacity.

Table 1

Projected Natural Gas Allotment*
for San Francisco International Airport
(As a Percentage of 1976)

Month	1977-78	1978-79
October	100	98
November	82	72
December	30	15
January	11	4
February	53	32
March	76	61
April	88	81
May	100	99
June	100	100
July	100	100
August	100	100
September	100	100

*From PG&E, San Mateo

9.2 Backup Space Heating System. Space heating in the proposed building will utilize a variable volume air-handling system. See Appendix B.

If the solar heat exchanger HE1 can keep the supply water to the hot deck equal to the solar set point (112°F.), then the backup system will not activate. Whenever the solar is not able to keep the hot deck supply water temperature above the backup set point (110°F.), the mixing valve at HE2 (the backup heat exchanger) will divert water through HE2 to be heated by the 200° secondary water loop.

9.3 Backup Domestic Hot Water System. Instantaneous heating of the domestic hot water delivered to load will provide the backup to a 6000 gallon solar domestic hot water storage tank. Water will first enter the solar storage tank and then pass through to the use points. Instantaneous boilers will provide any additional heating if necessary.

10. Control System Description

10.1 Collector to Storage Subsystem. The solar collectors mounted on the roof of the South Terminal West Addition will have water pumped through them when the collector temperature is greater than the water temperature in the bottom of the storage tank located in the basement of the terminal building.

A differential thermostat linked to a pump starter will accomplish the control. When there is no solar energy to collect, the pump will be turned off and the drain valve opened to prevent freezing problems. When there is solar energy to collect, the drain valve will be closed and the pump reactivated to circulate water from the bottom of the storage tank through the collectors.

See solar system schematics in Appendix B.

10.2 Storage to Space Heating Subsystem. A differential thermostat linked with the building thermostat will turn on pump P2 when the solar storage water is hotter than the return water from the hot deck. The building thermostat will then regulate valve V1 to maintain a supply water (to the hot deck) temperature of 112°F. If the supply water temperature cannot be kept above 110°F., the building thermostat will regulate valve V2 to maintain 110°F. supply water to the hot deck.

10.3 Storage to Domestic Hot Water Subsystem. A differential thermostat will sense when the solar storage tank water is hotter than the water in the bottom of the domestic hot water storage tank. Given this condition, the controller will turn on pump P5 and P6 affecting heat transfer through heat exchanger HE3, from the solar storage tank to the domestic hot water tank. If the domestic water tank is not warm enough, instantaneous heaters will bring the domestic hot water up to its required temperature on demand.

11. Plans and Drawings

Appendix B contains plans and drawings of the proposed building, the backup mechanical system, and the solar system and site views. As shown in the perspectives, there are no major obstacles existing or proposed which might shade the collectors.

12. System Manuals

The project consultants will prepare contract documents including working drawings, technical specifications, general conditions, supplementary general conditions, information for bidders, bid proposal and addenda to set forth in detail all aspects of design, function and construction. The contract documents will be used for estimating the project cost and securing construction bids.

A maintenance manual will be prepared containing the following information:

-- A list of all equipment including the manufacturer and catalog number, excepting pipe and fittings.

-- Manufacturers' instructions for all items requiring maintenance. Where the manufacturer's directions are not clear, are incomplete, or do not exist, additional information necessary to service, clean, adjust, etc., all of these items will be provided.

-- Training of maintenance personnel.

-- Operating instructions for all systems in lay terms and all variations in operating procedures.

13. Scope of Work

All the proposed work outlined in the cost proposal will be included in a subsequent cost-sharing contract. This work includes:

-- All professional services including structural and mechanical engineering associated with solar system design and construction.

-- All material and labor construction costs associated with the solar system including the cost of the solar collectors, their manifolding and supports, storage tanks, heat exchangers and all piping, pumps, valves and controls necessary for energy transfer and distribution between solar components.

-- Solar system acceptance testing.

-- Reports and meetings with DOE.

14. Structural Integrity

Final architectural and structural design has not been completed, but the South Terminal West Addition, as well as all future construction at the Airport, will be designed to support roof mounted solar collectors.

15. Warranties

The solar system installer will warrant the entire system against defects in materials and labor for one year as required by California State law and the provisions of the PON.

The baseline solar collectors are warranted by Solar Energy Products, Inc., as specified in the PON. See Appendix E for further details on Solar Energy Products, Inc. collector warranty. Similar warranty requirements will be required by all collector manufacturers who submit alternate collector bids.

APPENDIX A:

SYSTEM OPTIMIZATION ANALYSIS

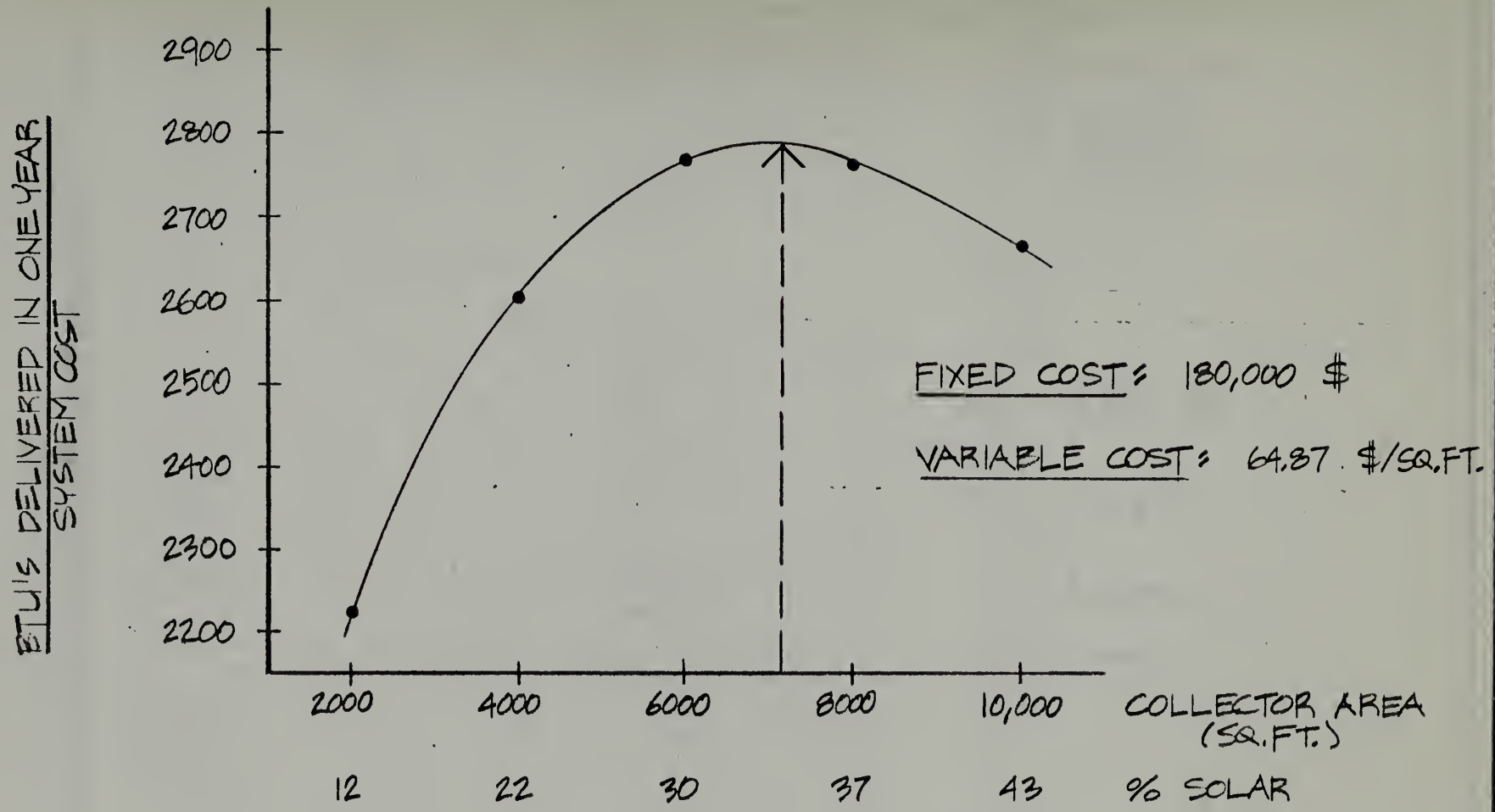


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fig. 2.1 system optimization

CODE	VARIABLE DESCRIPTION	VALUE	UNITS
1	AIR SYSTEM=1,LIQUID SYSTEM=2	2.00	
2	COLLECTOR AREA	7200.00	FT2
3	FRPRIME-TAU-ALPHA PRODUCT(NORMAL INCIDENCE)	.79	
4	FRPRIME-UL PRODUCT	1.10	BTU/H-F-F2
5	NUMBER OF TRANSPARENT COVERS	1.00	
6	COLLECTOR SLOPE	35.00	DEGREES
7	AZIMUTH ANGLE (E.G. SOUTH=0, WEST=90)	12.00	DEGREES
8	STORAGE CAPACITY	15.00	BTU/F-FT2
9	EFFECTIVE BUILDING UA	0.	BTU/HR-F
10	CONSTANT DAILY BLDG HEAT GENERATION	0.	BTU/DAY
11	(EPSILON)(CMIN)/(EFFECTIVE BUILDING UA)	1.00	
12	HOT WATER USAGE	5192.00	GAL/DAY
13	WATER SET TEMPERATURE	105.00	F
14	WATER MAIN TEMPERATURE	57.00	F
15	CITY CALL NUMBER	137.00	
16	THERMAL PRINT OUT BY MONTH=1, BY YEAR=2	1.00	
17	ECONOMIC ANALYSIS < YES=1, NO=2	1.00	
18	USE OPTMZD. COLLECTOR AREA=1, SPECFD. AREA=2.	2.00	
19	SOLAR SYSTEM THERMAL PERFORMANCE DECRADATION.	0.	%/YR
20	PERIOD OF THE ECONOMIC ANALYSIS	30.00	YEARS
21	COLLECTOR AREA DEPENDENT SYSTEM COSTS	0.	$/FT2 COLL
22	CONSTANT SOLAR COSTS	647095.00	$
23	DOWN PAYMENT(% OF ORIGINAL INVESTMENT)	100.00	%
24	ANNUAL INTEREST RATE ON MORTGAGE	0.	%
25	TERM OF MORTGAGE	1.00	YEARS
26	ANNUAL NOMINAL(MARKET) DISCOUNT RATE	5.00	%
27	EXTRA INSUR.,MAINT. IN YEAR 1(% OF ORIG.INV.)	1.00	%
28	ANNUAL % INCREASE IN ABOVE EXPENSES	7.00	%
29	PRESENT COST OF SOLAR BACKUP FUEL (BF)	4.03	$/MMBTU
30	BF RISES %/YR=1,SEQUENCE OF VALUES=2	1.00	
31	IF 1, WHAT IS THE ANNUAL RATE OF BF RISE	15.00	%
32	PRESENT COST OF CONVENTIONAL FUEL (CF)	4.03	$/MMBTU
33	CF RISES %/YR=1,SEQUENCE OF VALUES=2	1.00	
34	IF 1, WHAT IS THE ANNUAL RATE OF CF RISE	15.00	%
35	ECONOMIC PRINT OUT BY YEAR=1, CUMULATIVE=2	1.00	
36	EFFECTIVE FEDERAL-STATE INCOME TAX RATE	0.	%
37	TRUE PROP. TAX RATE PER $ OF ORIGINAL INVEST.	0.	%
38	ANNUAL % INCREASE IN PROPERTY TAX RATE	0.	%
39	CALC.RT. OF RETURN ON SOLAR INVTMT<YES=1,NO=2	1.00	
40	SALVAGE VALUE (% OF ORIGINAL INVESTMENT)	30.00	%
41	INCOME PRODUCING BUILDING< YES=1,NO=2	2.00	

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fig. 2.2 fchart input data

SAN FRANCISCO CA 37.47

****THERMAL ANALYSIS****

TIME	PERCENT SOLAR	INCIDENT SOLAR (MMBTU)	HEATING LOAD (MMBTU)	WATER LOAD (MMBTU)	DEGREE DAYS (F-DAY)	AMBIENT TEMP (F)
JAN	11.7	256.97	956.64	64.54	437.	50.
FEB	21.8	296.59	628.09	58.29	325.	54.
MAR	33.9	407.41	557.23	64.54	332.	54.
APR	46.0	421.05	392.96	62.46	291.	55.
MAY	70.2	436.68	202.92	64.54	257.	57.
JUN	88.6	414.71	106.29	62.46	194.	59.
JUL	92.8	397.22	74.08	64.54	202.	59.
AUG	92.9	384.23	67.64	64.54	177.	59.
SEP	98.5	381.64	51.54	62.46	102.	63.
OCT	65.7	369.48	177.15	64.54	127.	61.
NOV	26.5	288.65	460.71	62.46	233.	57.
DEC	13.1	240.33	753.71	64.54	403.	52.
YR	34.6	4294.98	4428.98	759.91	3080.	

fig. 2.3 fchart thermal analysis

****ECONOMIC ANALYSIS****
SPECIFIED COLLECTOR AREA = 7200. FT2
INITIAL COST OF SOLAR SYSTEM = $ 647095.
THE ANNUAL MORTGAGE PAYMENT FOR 1 YEARS = $ 0.

YR	INTRST PAID	END OF YR PRINC	DEPRC DEDUCT	PROP TAX PAID	INC TAX SAVED	BACKUP FUEL COST	INSUR, MAINT COST	COST WITH SOLAR	SAVNGS WITH SOLAR	PW OF SOLAR SAVNGS
1	0	0	0	0	0	13678	6470	667244	-646334	-646370
2	0	0	0	0	0	15730	6923	22654	1393	1263
3	0	0	0	0	0	18090	7409	25498	2156	1862
4	0	0	0	0	0	20803	7927	28730	3072	2527
5	0	0	0	0	0	23924	8482	32406	4167	3265
6	0	0	0	0	0	27513	9075	36588	5471	4082
7	0	0	0	0	0	31639	9711	41351	7017	4987
8	0	0	0	0	0	36385	10390	46776	8847	5988
9	0	0	0	0	0	41843	11118	52962	11005	7094
10	0	0	0	0	0	48120	11896	60017	13546	8316
11	0	0	0	0	0	55338	12729	68067	16529	9664
12	0	0	0	0	0	63639	13620	77259	20027	11152
13	0	0	0	0	0	73185	14573	87758	24121	12792
14	0	0	0	0	0	84162	15593	99756	28905	14599
15	0	0	0	0	0	96787	16685	113472	34488	16589
16	0	0	0	0	0	111305	17853	129159	40996	18781
17	0	0	0	0	0	128001	19103	147104	48574	21193
18	0	0	0	0	0	147201	20440	167642	57389	23846
19	0	0	0	0	0	169281	21871	191153	67632	26764
20	0	0	0	0	0	194674	23402	218076	79527	29973
21	0	0	0	0	0	223875	25040	248915	93328	33499
22	0	0	0	0	0	257456	26793	284249	109331	37374
23	0	0	0	0	0	296074	28668	324743	127874	41632
24	0	0	0	0	0	340486	30675	371161	149349	46308
25	0	0	0	0	0	391558	32823	424382	174205	51443
26	0	0	0	0	0	450292	35120	485413	202962	57081
27	0	0	0	0	0	517836	37579	555415	236216	63270
28	0	0	0	0	0	595512	40209	635721	274655	70062
29	0	0	0	0	0	684839	43024	727863	319070	77516
30	0	0	0	0	0	787564	46036	839472	564501	130612

THE DISCOUNTED RATE OF RETURN ON THE SOLAR INVESTMENT(*)= 6.1
THE DISCOUNTED PAYBACK PERIOD IS(YR) 29.
YRS UNTIL CUMULATIVE SAVINGS=MORTGAGE PRINCIPLE 29.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH SOLAR = $ 2807293.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O SOLAR = $ 2994470.
PRESENT WORTH OF CUMULATIVE SOLAR SAVINGS = $ 187177.

fig. 2.4 fchart economic analysis

APPENDIX B:

PLANS AND DRAWINGS

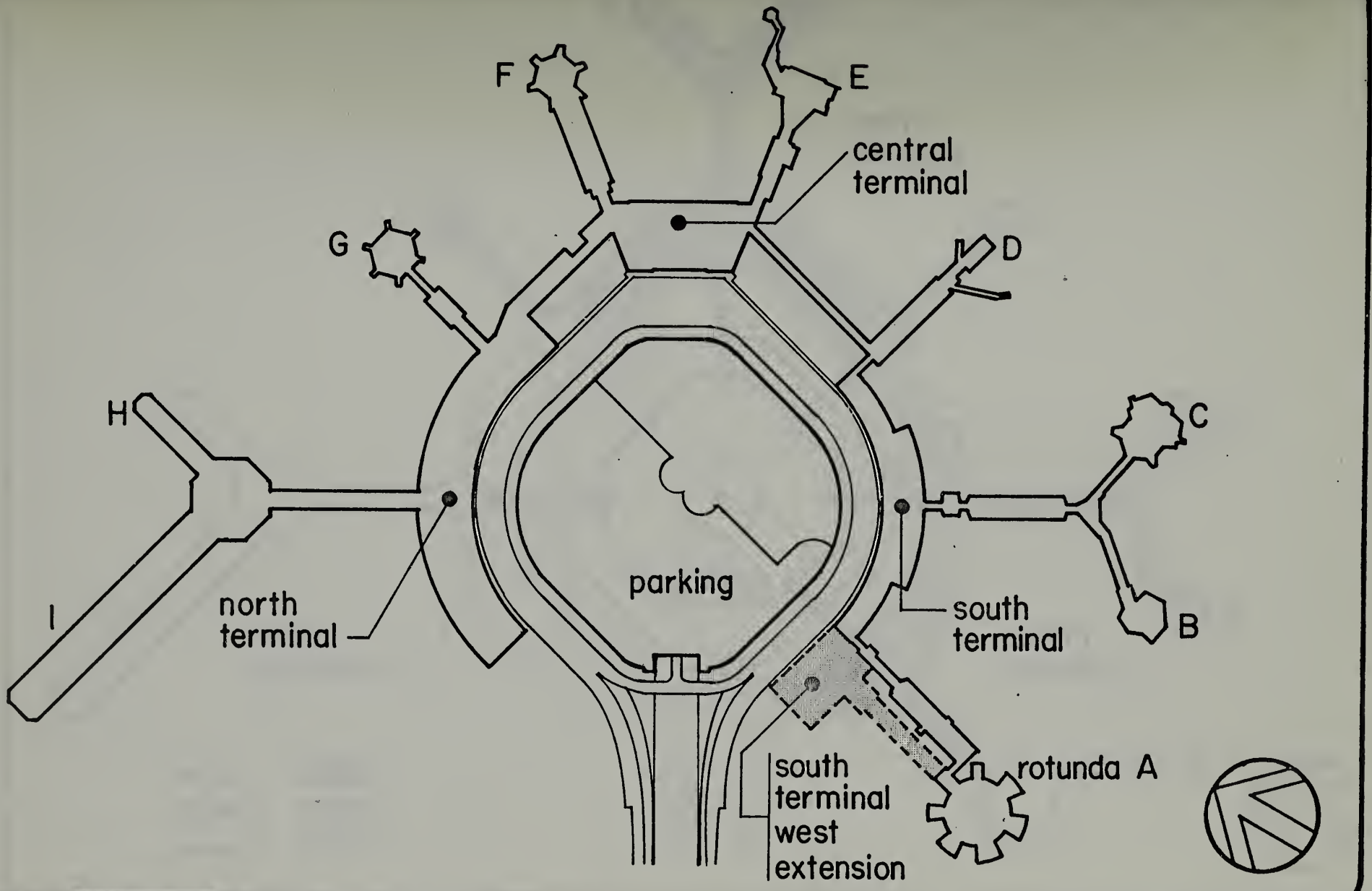

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fig. 2.5 existing site plan

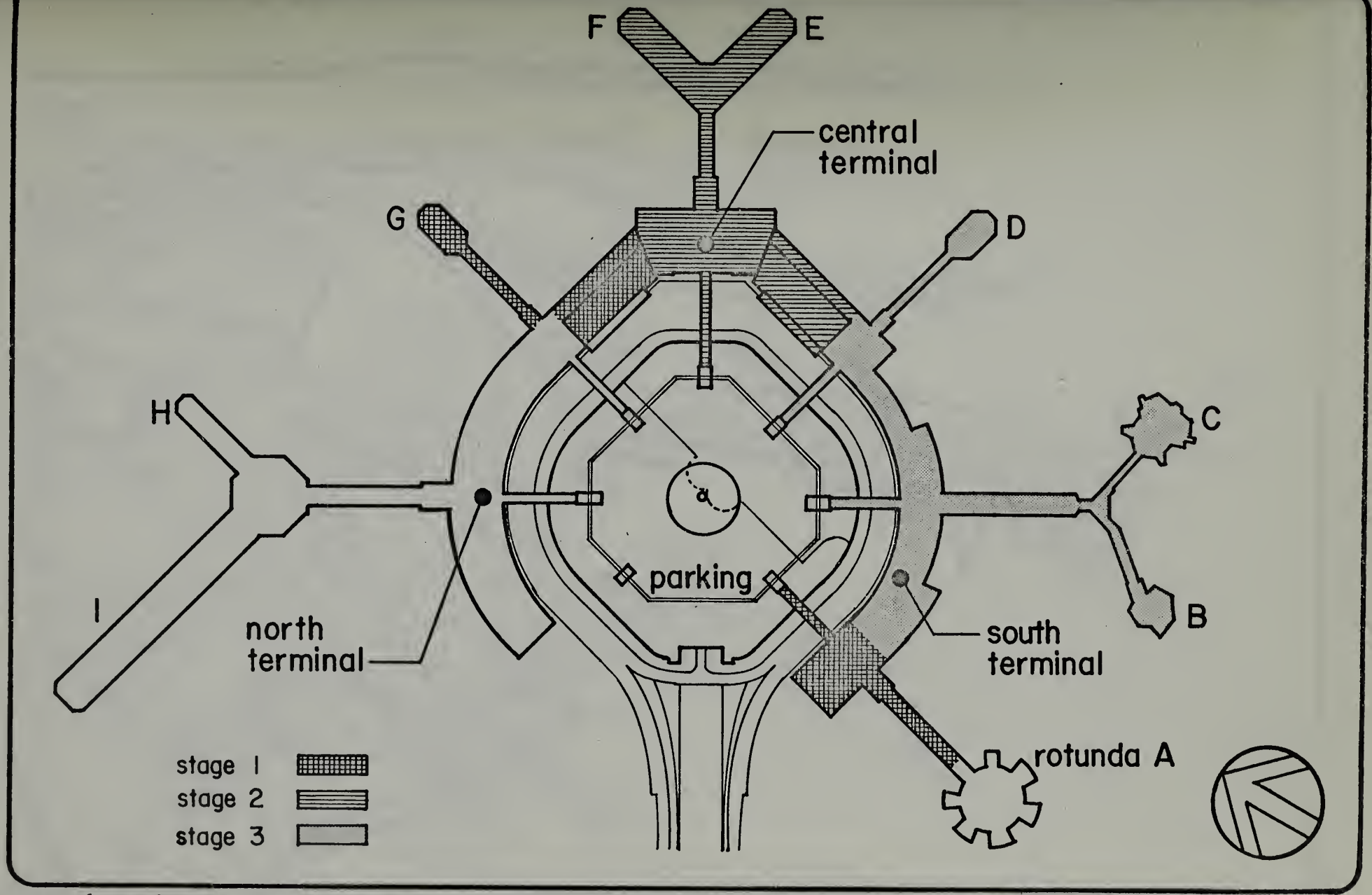

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fig. 2.6

modernization and replacement phase

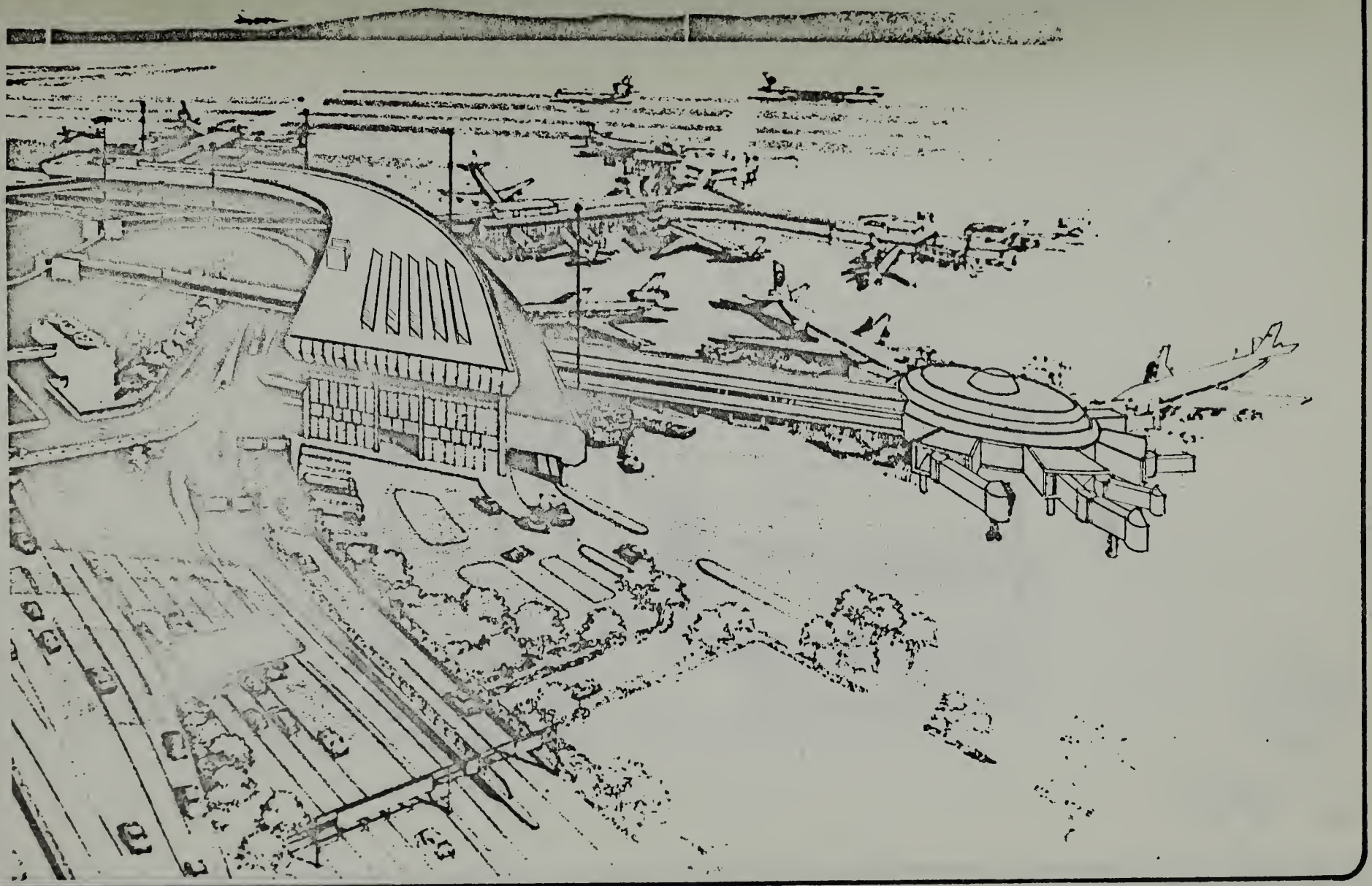

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fig. 2.7 — perspective of south terminal west extension

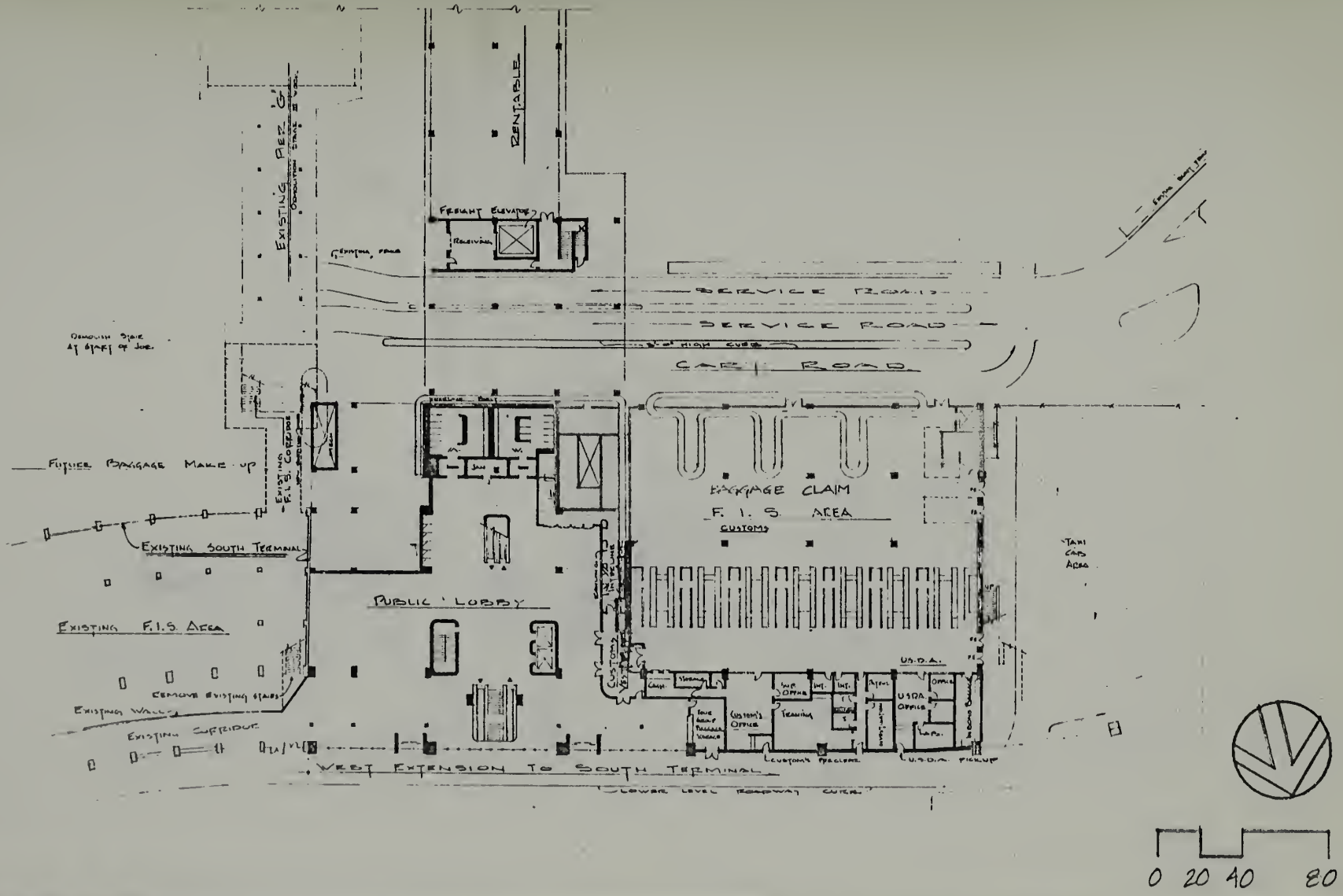

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fig. 2.8

ground floor plan

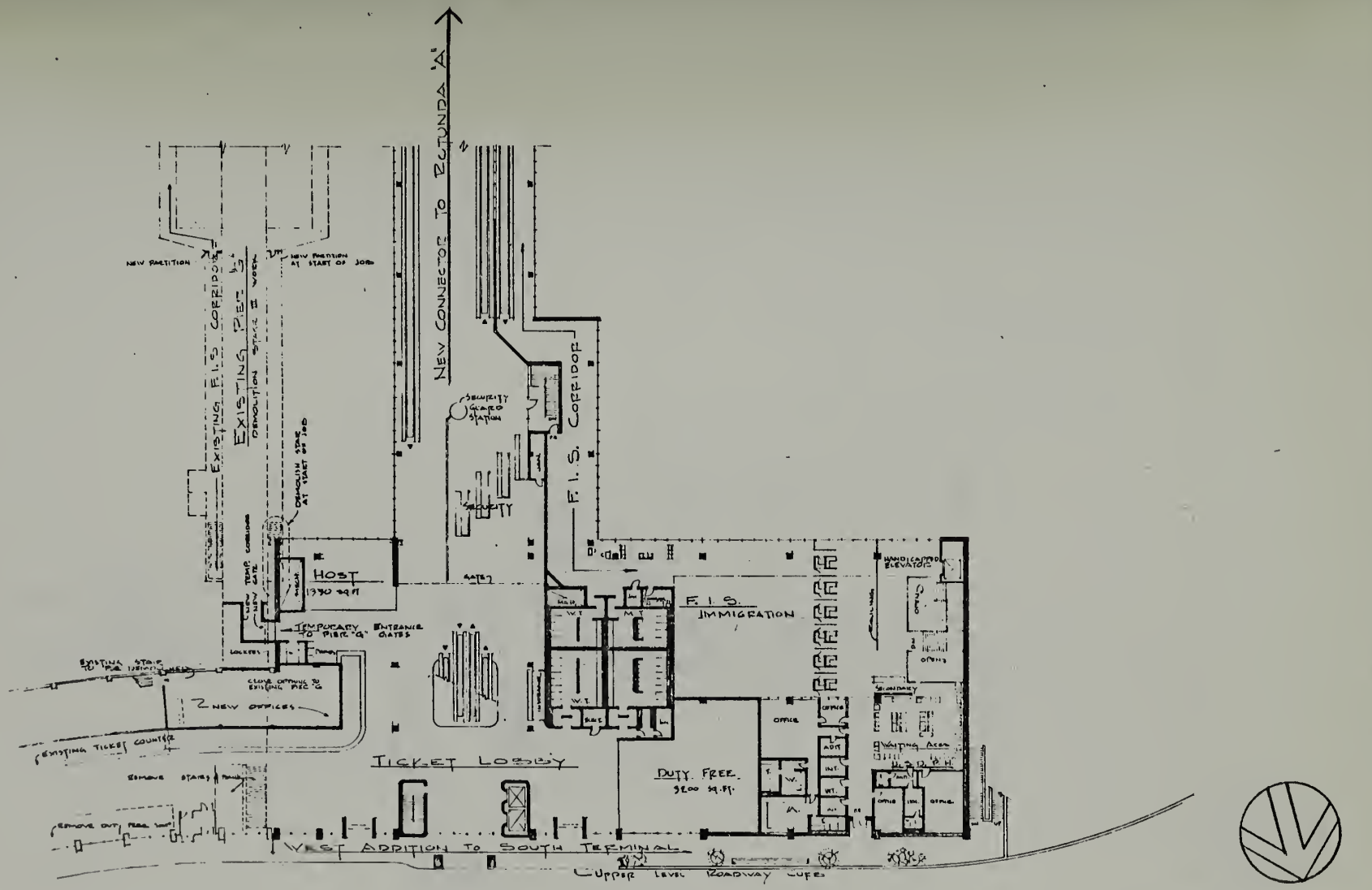

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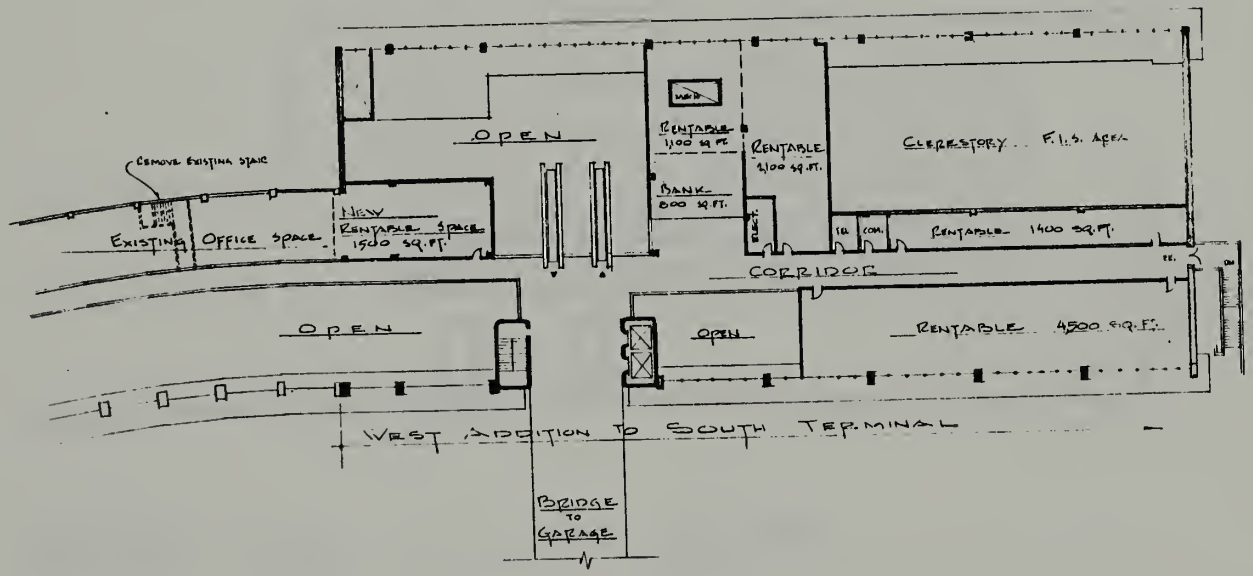
fig. 2.9

second floor plan



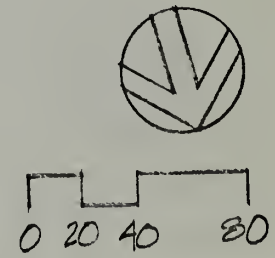


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fig. 2.10

mezzanine floor plan

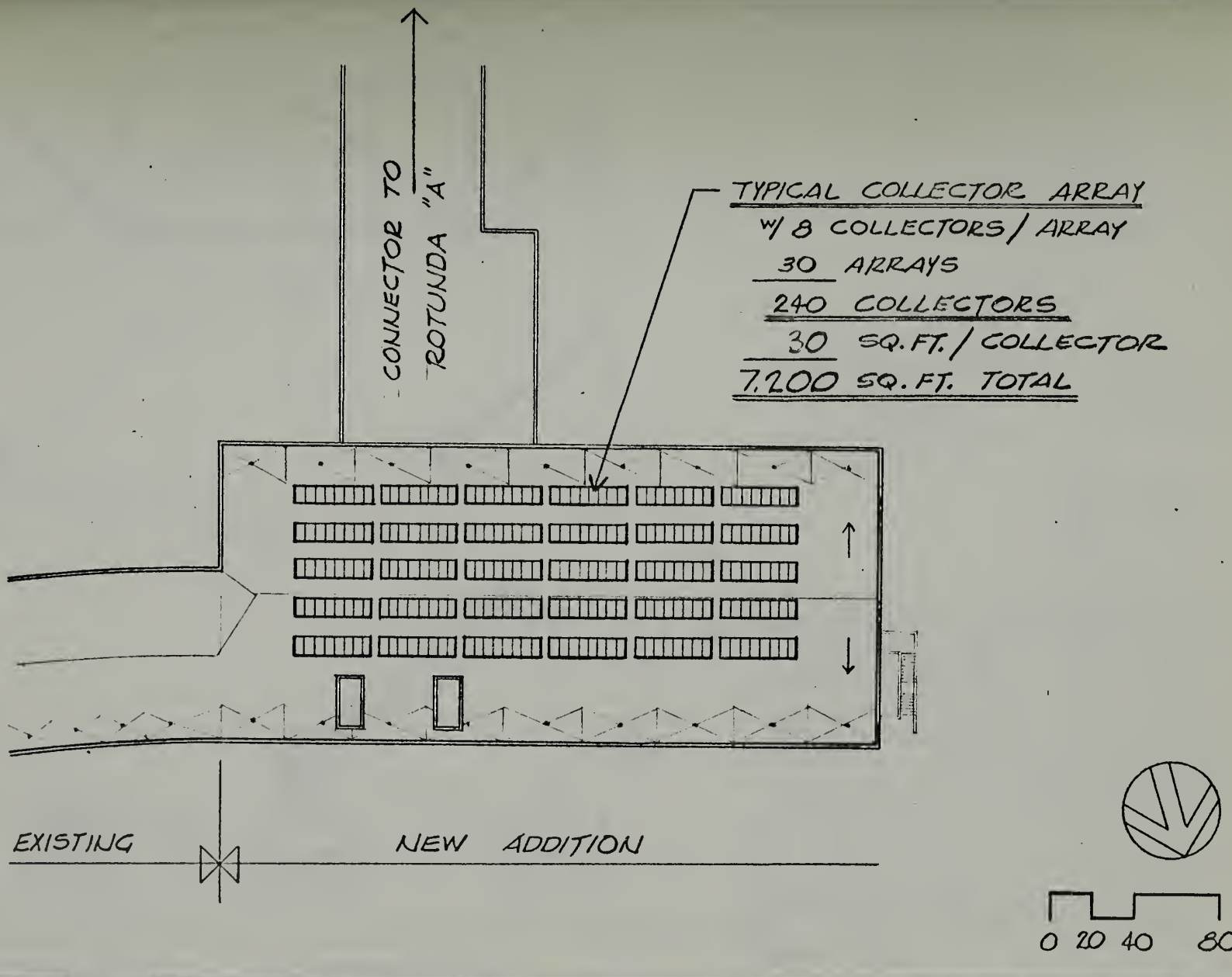

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fig. 2.11

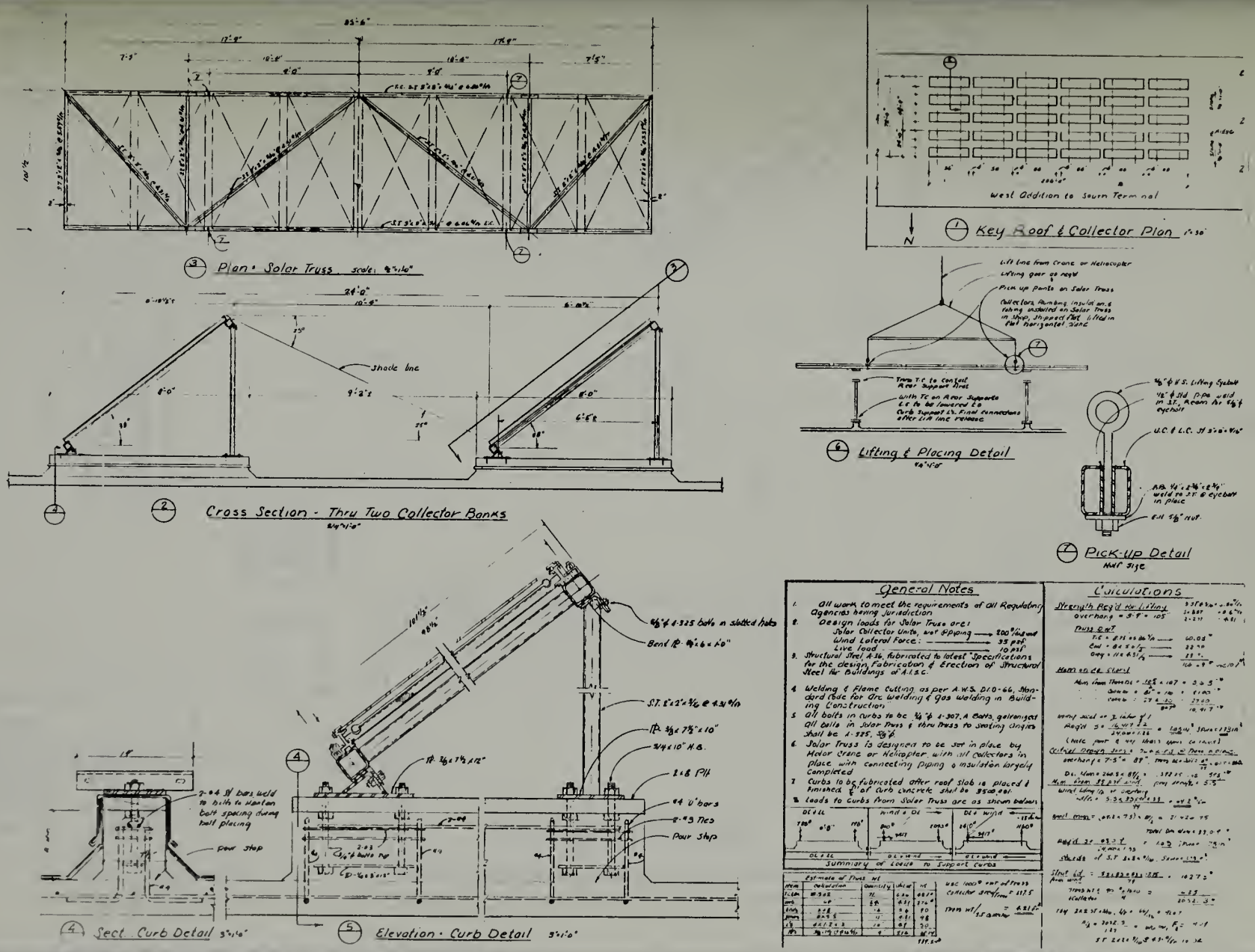

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fig. 2.12

solar collector support truss

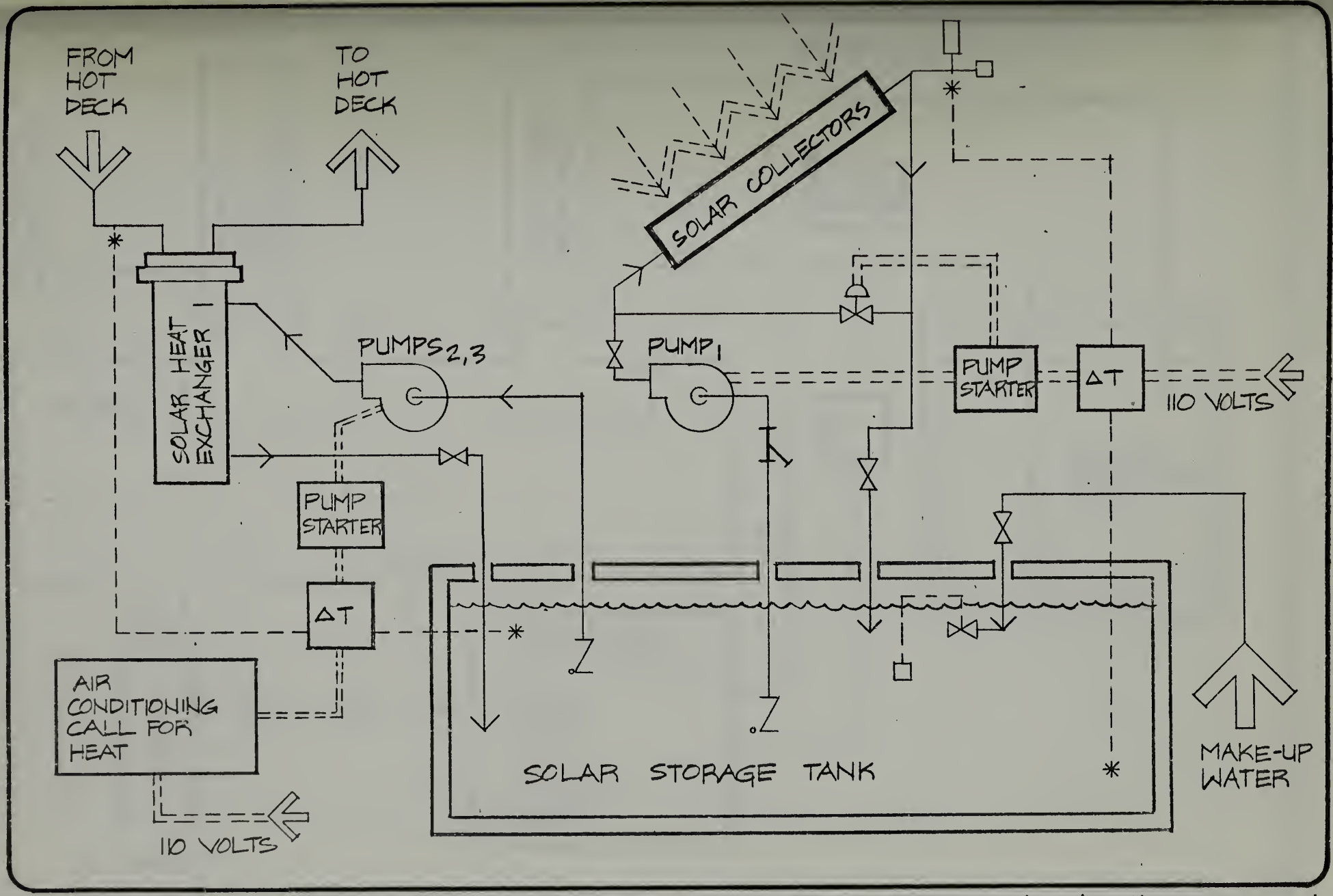

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fig. 2.13 — solar system schematic

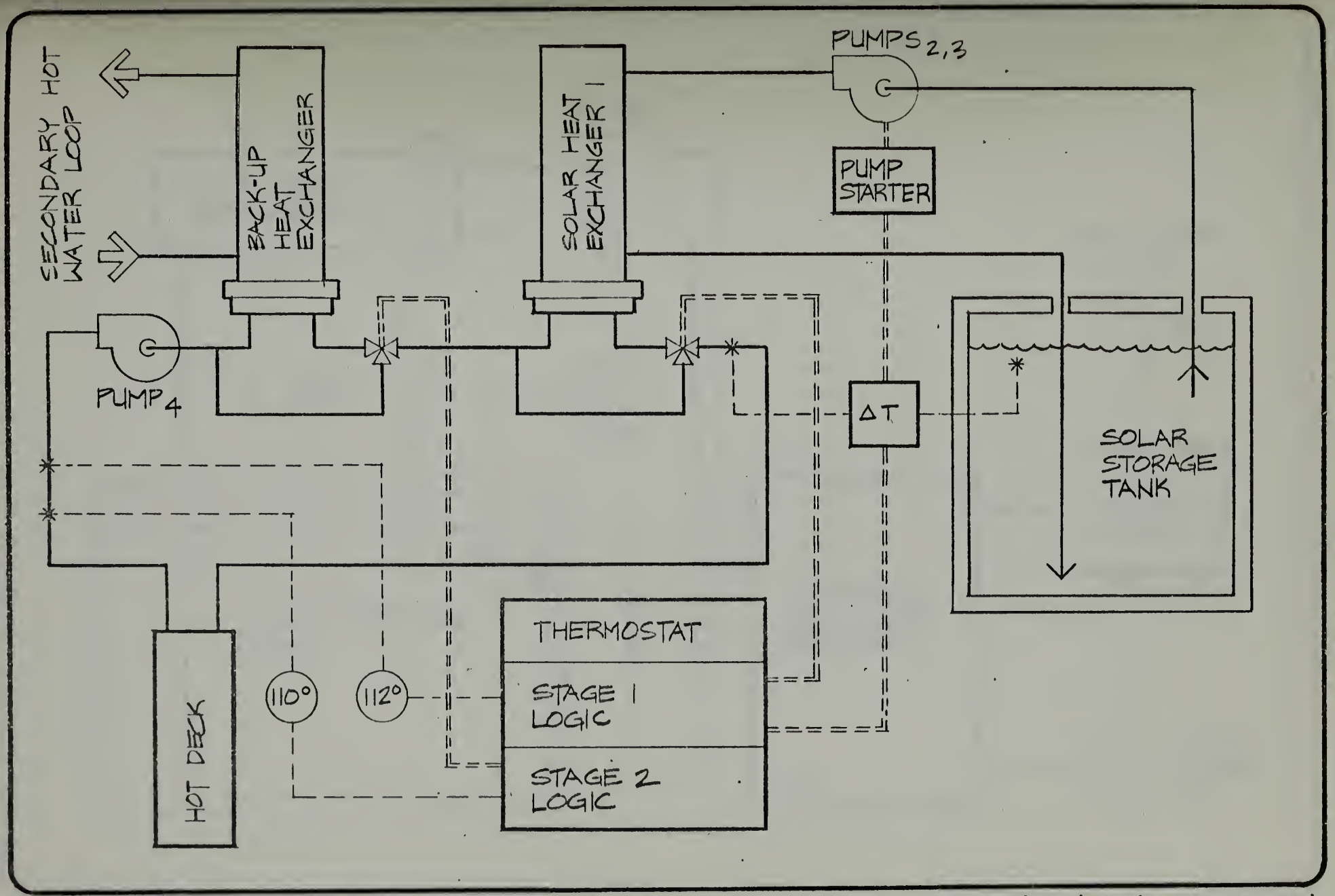

fig. 2.14 solar space heating schematic

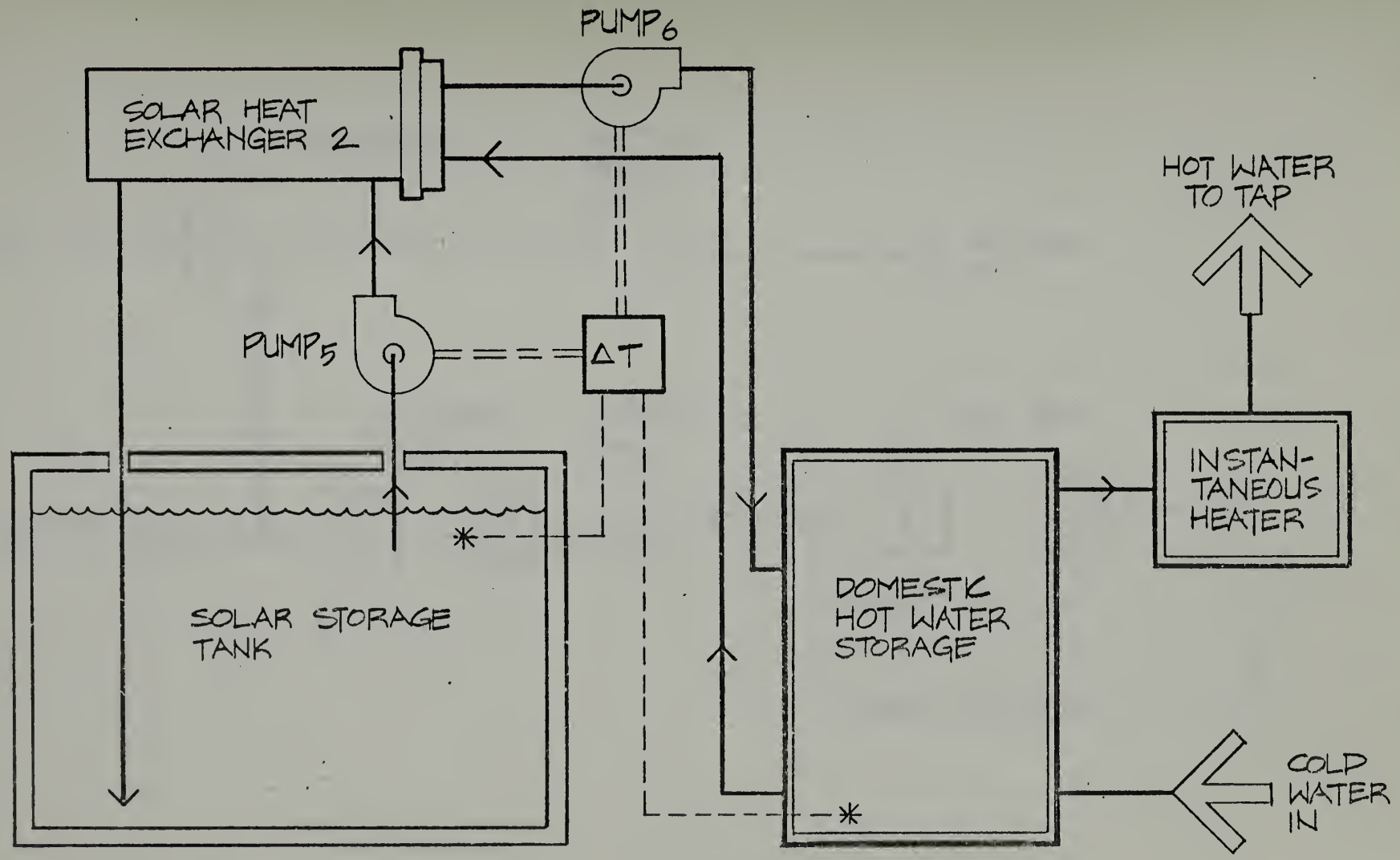

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fig. 2.15 solar domestic hot water schematic

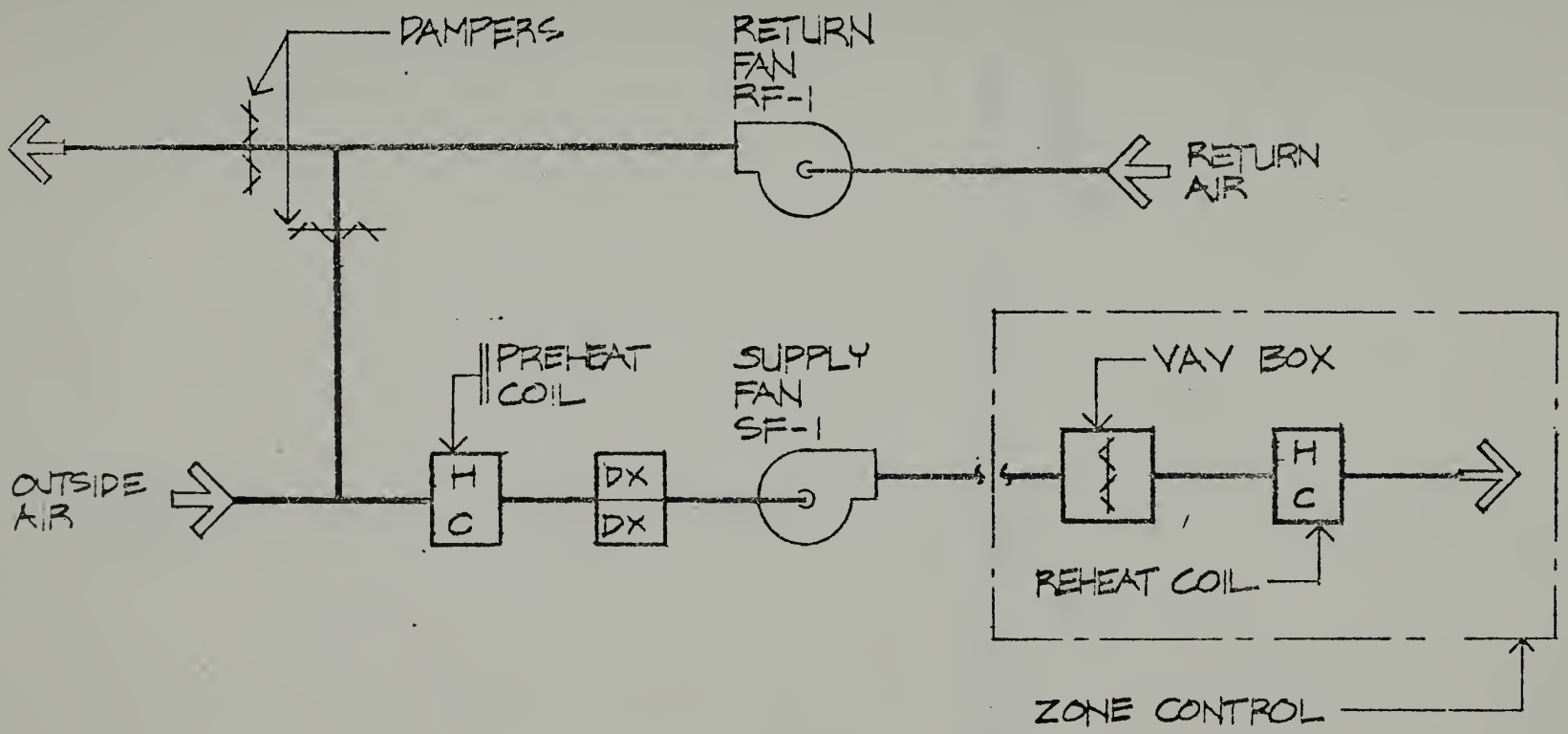

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fig. 2.16 variable volume air handling system (back-up system)

APPENDIX C:

BASELINE COLLECTOR PERFORMANCE TEST DATA

DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 9, 1977
COLLECTOR: CUS, GF 17006S
GLAZING: Single Glass
APERTURE AREA: 29.9 ft^2

TEST METHOD: DSET 75SE2.7 (ASHRAE 93-P/ENI)

t, solar	1222	1229	1245	1252	1402
$\dot{m}$ (lb/hr)	372.5	369.9	368.8	368.3	373.3
$\int T_i$ (°F)	(204.7) 3070.7	(204.6) 3069.1	(204.4) 3066.1	(204.3) 3064.8	(162.2) 2433.4
$\int T_o$ (°F)	(211.6) 3174.0	(211.5) 3172.3	(211.5) 3172.4	(211.5) 3172.1	(172.9) 2593.7
T_p (°F)	-	-	-	-	-
T_p (°F)	-	-	-	-	-
T_p (°F)	-	-	-	-	-
$\int T_a$ (°F)	(46.2) 693.3	(46.8) 701.6	(46.8) 702.1	(47.3) 708.9	(48.5) 727.1
Wind Velocity	N 7	E 7	NE 8	N 4	N 8
Air Over Collector (fpm)	410	200	480	470	400
C_p (BTU/lb.°F)	1.00637	1.00635	1.00635	1.00632	1.00148
$\int q_i$ (BTU/FT^2.hr)	(338.9) 5083.2	(339.0) 5084.6	(337.9) 5069.1	(337.9) 5068.0	(324.9) 4873.5
q_i, % Diffuse	5.5	5.5	5.5	5.6	5.8
Tilt Angle	54.4	54.6	55.1	55.4	61.1
Incidence Angle	0°	0°	0°	0°	0°
Azimuth Angle	-5.1	-7.1	-11.6	-13.5	-31.4
P_{in} (psi)	13.3	13.3	13.2	13.2	13.8
ΔP (psi)	3.2	3.2	3.2	3.2	3.3
$\int \Delta T$ (°F)	(6.9) 103.2	(6.9) 103.1	(7.1) 106.3	(7.2) 107.3	(10.7) 160.3
$\bar{T}_f$ (°F)	208.2	208.0	208.0	207.9	167.6
T_p (°F)	-	-	-	-	-
$T_f - T_a$ (°F)	161.9	161.3	161.1	160.6	119.1
$T_p - T_a$ (°F)	-	-	-	-	-
$T_i - T_a$ (°F)	158.5	157.8	157.6	157.0	113.7
$(T_f - T_a)/q_i$*	0.478	0.476	0.477	0.475	0.367
$(T_i - T_a)/q_i$*	0.468	0.466	0.466	0.465	0.350
$(T_p - T_a)/q_i$*	-	-	-	-	-
η_{q_i}**	-	-	-	-	-
Efficiency, η	0.255	0.252	0.260	0.262	0.411

*°F/BTU/FT^2.hr **BTU/FT^2.hr

DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 105, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 9, 1977
COLLECTOR: CUS, GF 17006S
GLAZING: Single Glass
APERTURE AREA: 29.9 ft^2

TEST METHOD: DSET 75SE2.7 (ASHRAE 93-P/ENI)

t, solar	1530	1537			
$\dot{m}$ (lb/hr)	376.0	373.4			
$\int T_i$ (°F)	(54.4) 816.1	(54.4) 815.3			
$\int T_o$ (°F)	(70.7) 1059.9	(70.3) 1053.9			
T_p (°F)	-	-			
T_p (°F)	-	-			
T_p (°F)	-	-			
$\int T_a$ (°F)	(49.7) 744.8	(49.4) 741.4			
Wind Velocity	NE 6	N 5			
Air Over Collector (fpm)	200	90			
C_p (BTU/lb.°F)	0.99933	0.99937			
$\int q_i$ (BTU/FT^2.hr)	(275.3) 4130.1	(268.1) 4021.7			
q_i, % Diffuse	5.0	5.0			
Tilt Angle	73.2	74.4			
Incidence Angle	0°	0°			
Azimuth Angle	-49.2	-50.4			
P_{in} (psi)	14.8	14.8			
ΔP (psi)	3.7	3.8			
$\int \Delta T$ (°F)	(16.2) 243.7	(15.9) 238.6			
$\bar{T}_f$ (°F)	62.5	62.3			
T_p (°F)	-	-			
$T_f - T_a$ (°F)	12.9	12.9			
$T_p - T_a$ (°F)	-	-			
$T_i - T_a$ (°F)	4.7	4.0			
$(T_f - T_a)/q_i$*	0.047	0.048			
$(T_i - T_a)/q_i$*	0.017	0.015			
$(T_p - T_a)/q_i$*	-	-			
η_{q_i}**	-	-			
Efficiency, η	0.742	0.740			

*°F/BTU/FT^2.hr **BTU/FT^2.hr

DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 170065
REPORT NO.: 7750109A

DATE: January 10, 1977
COLLECTOR: CUS, GF 17006S
GLAZING: Single Glass
APERTURE AREA: 29.9 ft^2

TEST METHOD: DSET 75SE2.7 (ASHRAE 93-P/ENI)

t, solar	1147	1247	1254	1310	
$\dot{m}$ (lb/hr)	375.6	375.0	373.5	373.0	
$\int T_i$ (°F)	(108.6) 1629.7	(108.3) 1623.8	(108.2) 1623.4	(108.3) 1625.2	
$\int T_o$ (°F)	(126.0) 1890.4	(125.3) 1879.0	(124.2) 1863.3	(125.2) 1878.1	
T_p (°F)	-	-	-	-	
T_p (°F)	-	-	-	-	
T_p (°F)	-	-	-	-	
$\int T_a$ (°F)	(52.2) 782.8	(52.6) 789.1	(53.4) 801.4	(54.2) 813.7	
Wind Velocity	0	S 5	S 3	S 2	
Air Over Collector (fpm)	0	310	220	0	
C_p (BTU/lb.°F)	0.99838	0.99836	0.99834	0.99836	
$\int q_i$ (BTU/FT^2.hr)	(342.7) 5140.7	(330.1) 4952.1	(316.0) 4740.4	(343.5) 5151.9	
q_i, % Diffuse	12.7	10.7	11.1	8.5	
Tilt Angle	54.3	55.1	55.4	56.0	
Incidence Angle	0°	0°	0°	0°	
Azimuth Angle	4.9	-12.2	-14.1	-17.1	
P_{in} (psi)	14.3	14.0	14.2	14.0	
ΔP (psi)	3.1	3.2	3.4	3.3	
$\int \Delta T$ (°F)	(17.4) 260.7	(17.0) 255.2	(16.0) 239.8	(16.9) 252.9	
T_f (°F)	117.3	116.8	116.2	116.8	
T_p (°F)	-	-	-	-	
T_f-T_a (°F)	65.1	64.2	62.8	62.5	
T_p-T_a (°F)	-	-	-	-	
T_i-T_a (°F)	56.4	55.7	54.8	54.1	
$(T_f-T_a)/q_i$*	0.190	0.194	0.199	0.182	
$(T_i-T_a)/q_i$*	0.165	0.169	0.173	0.157	
$(T_p-T_a)/q_i$*	-	-	-	-	
η_{q_i}**	-	-	-	-	
Efficiency, η	0.636	0.645	0.631	0.611	

*°F/BTU/FT^2.hr **BTU/FT^2.hr

Mean values in parentheses.

DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 10, 1977
COLLECTOR: CUS, GF 17006S
GLAZING: Single Glass
APERTURE AREA: 29.9 ft^2

TEST METHOD: DSET 75SE2.7 - Incident Angle Modifier

t, solar	1507	1512	1552	1557	
$\dot{m}$ (lb/hr)	364.9	363.9	362.0	363.0	
$\int T_i$ (°F)	(55.5) 277.5	(55.6) 277.9	(55.5) 277.5	(55.4) 277.0	
$\int T_o$ (°F)	(68.4) 341.8	(68.2) 340.8	(62.7) 313.4	(62.4) 312.1	
T_p (°F)	-	-	-	-	
T_p (°F)	-	-	-	-	
T_p (°F)	-	-	-	-	
$\int T_a$ (°F)	(54.6) 273.1	(55.2) 275.8	(53.1) 265.5	(52.6) 262.9	
Wind Velocity	SW 6	SW 6	S 5	S 5	
Air Over Collector (fpm)	350	210	210	250	
C_p (BTU/lb.°F)	0.99942	0.99942	0.99974	0.99979	
$\int q_i$ (BTU/FT^2.hr)	(206.6) 1032.8	(205.0) 1025.2	(125.6) 627.9	(122.4) 612.0	
q_i, % Diffuse	-	-	-	-	
Tilt Angle	-	-	-	-	
Incidence Angle	45°	45°	60°	60°	
Azimuth Angle	-	-	-	-	
P_{in} (psi)	13.7	13.7	13.8	13.5	
ΔP (psi)	3.6	3.7	3.6	3.5	
$\int \Delta T$ (°F)	(12.9) 64.3	(12.6) 62.9	(7.2) 35.9	(7.0) 35.1	
$\bar{T}_f$ (°F)	61.9	61.9	59.1	58.9	
T_p, (°F)	-	-	-	-	
$\bar{T}_f - T_a$ (°F)	7.3	6.7	6.0	6.3	
$\bar{T}_p - T_a$ (°F)	-	-	-	-	
$T_i - T_a$ (°F)	0.9	0.4	2.4	2.8	
$(T_f - T_a)/q_i$*	0.035	0.033	0.048	0.052	
$(T_i - T_a)/q_i$*	0.001	0.002	0.019	0.023	
$(T_p - T_a)/q_i$*	-	-	-	-	
η_{q_i}**	-	-	-	-	
Efficiency, η	0.750	0.746	0.692	0.696	

*°F/(BTU/FT^2.hr) **FT^2.hr/BTU

DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 11, 1977
COLLECTOR: CUS, GF 17006S
GLAZING: Single Glass
APERTURE AREA: 29.9 ft^2

TEST METHOD: DSET 75SE2.7 - Incident Angle Modifier

t, solar	1102	1107			
$\dot{m}$ (lb/hr)	389.9	381.9			
$\int T_i$ (°F)	(59.1) 295.4	(59.2) 295.9			
$\int T_o$ (°F)	(62.4) 312.0	(62.5) 312.5			
T_p (°F)	-	-			
T_p (°F)	-	-			
T_p (°F)	-	-			
$\int T_a$ (°F)	(57.5) 287.4	(57.5) 288.5			
Wind Velocity	N 13	N 12			
Air Over Collector (fpm)	880	1160			
C_p (BTU/lb.°F)	0.99955	0.99955			
$\int q_i$ (BTU/FT^2.hr)	(100.6) 503.0	(98.9) 494.4			
q_i, % Diffuse	-	-			
Tilt Angle	-	-			
Incidence Angle	75°	75°			
Azimuth Angle	-	-			
P_{in} (psi)	12.4	12.4			
ΔP (psi)	3.5	3.5			
$\int \Delta T$ (°F)	(3.3) 16.6	(3.3) 16.6			
$\bar{T}_f$ (°F)	60.7	60.8			
T_p (°F)	-	-			
$\bar{T}_f - T_a$ (°F)	3.2	3.1			
$\bar{T}_p - T_a$ (°F)	-	-			
$T_i - T_a$ (°F)	1.6	1.7			
$(T_f - T_a)/q_i$*	0.032	0.032			
$(T_i - T_a)/q_i$*	0.016	0.017			
$(T_p - T_a)/q_i$*	-	-			
ηq_i**	-	-			
Efficiency, η	0.431	0.428			

*°F/BTU/FT^2.hr **BTU/FT^2.hr

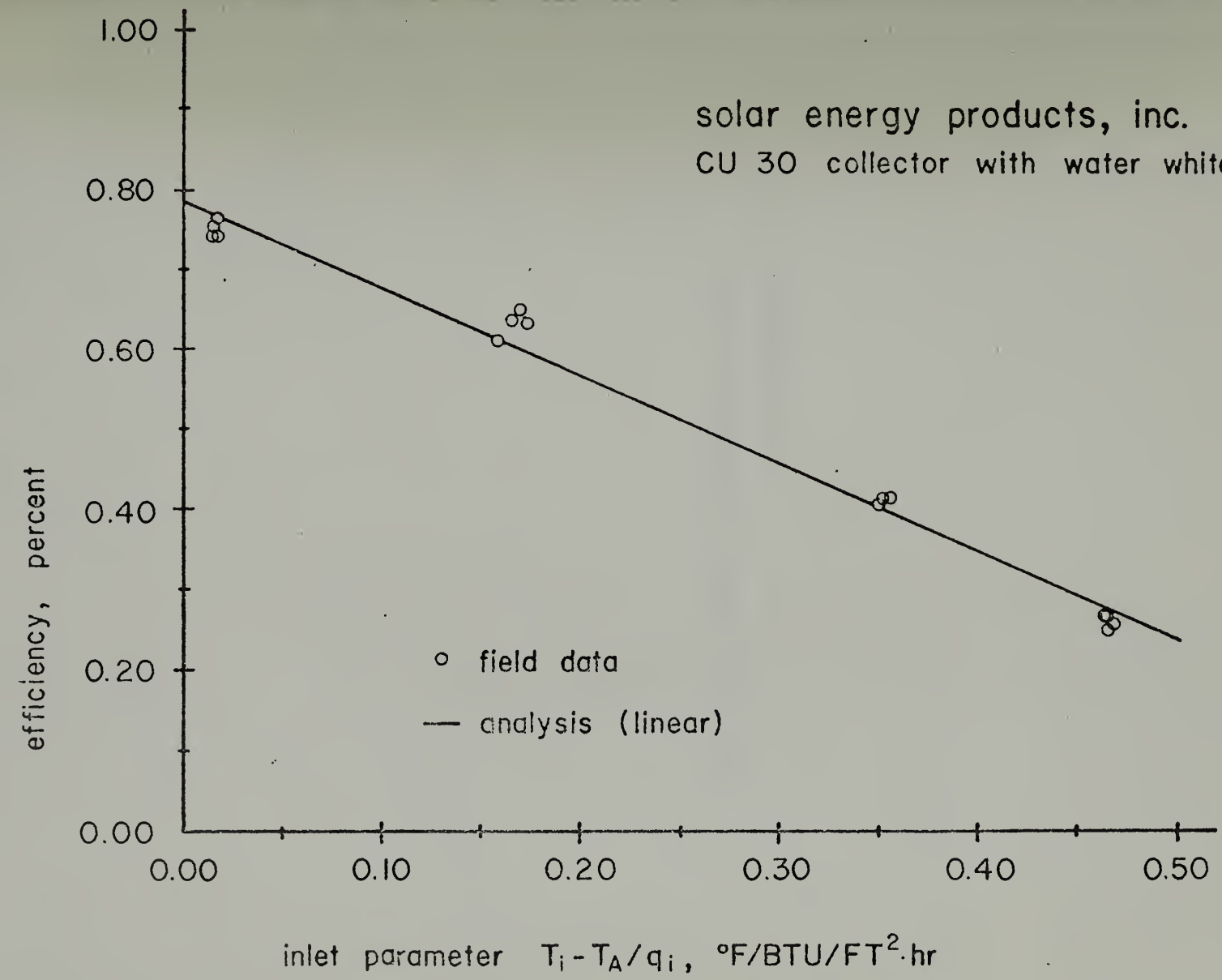

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fig. 2.17 collector performance curve - inlet parameter

APPENDIX D:

BASELINE COLLECTOR CATALOGUE CUTS

FEATURES: CU30 FLAT PLATE SOLAR COLLECTOR

FEATURE FOR FEATURE — The Gulf Thermal CU30 is carefully designed and constructed of the finest quality materials to provide dependable performance with a maximum service life expectancy.

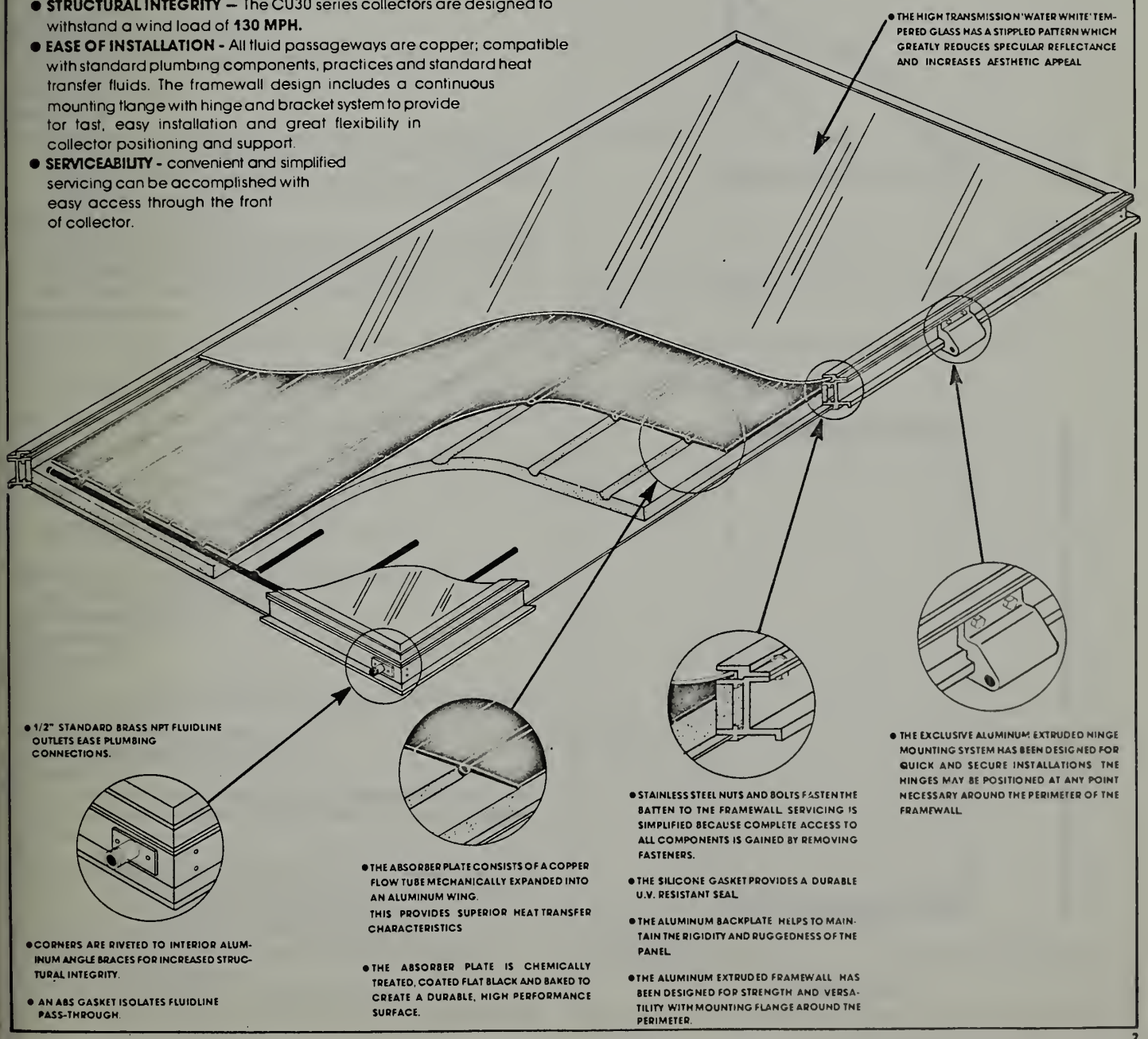
- **PERFORMANCE** — Our advanced design absorber plate combines copper flow tubes mechanically expanded into a highly conductive aluminum extruded wing, closed cell isocyanurate insulation, high transmissivity tempered glass cover plate, and a highly absorptive durable plate coating assuring outstanding thermal performance **(See Test Analysis page 5).** The CU30 may be used in open or closed systems with **working pressures to 150 p.s.i.** and provides **thermal performance stability to 300°F.** An outstanding feature of the CU30 is the advanced design of the custom aluminum extruded framewall. The framewall has been designed for strength and versatility in mounting, in either saw-tooth or integrated roofing applications.
- **DURABILITY** — The anodized aluminum frame, non-degrading tempered glass cover plate, water-resistant closed cell insulation, silicone gaskets, and copper flow passageways all provide for design service life of **30 years,** when properly operated.
- **STRUCTURAL INTEGRITY** — The CU30 series collectors are designed to withstand a wind load of **130 MPH.**
- **EASE OF INSTALLATION** - All fluid passageways are copper; compatible with standard plumbing components, practices and standard heat transfer fluids. The framewall design includes a continuous mounting flange with hinge and bracket system to provide for fast, easy installation and great flexibility in collector positioning and support.
- **SERVICEABILITY** - convenient and simplified servicing can be accomplished with easy access through the front of collector.

SEP Systems have been designed and constructed to meet:

- **The Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems (NBSIR-76-1059)**
- **HUD Minimum Property Standards for Solar Heating and Domestic Hot Water Systems (4930.2).**
- **Independent Testing has been conducted by DESERT SUNSHINE EXPOSURE TESTS, INC., in accordance with The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE 93—77) guidelines.**

WARRANTY

The CU30 Modular Solar Collector is warranted against defects in materials and workmanship for five years from date of purchase (except for freeze damage, glass breakage and damage due to aggressive heat transfer fluid).


• THE HIGH TRANSMISSION 'WATER WHITE' TEMPERED GLASS HAS A STIPPLED PATTERN WHICH GREATLY REDUCES SPECULAR REFLECTANCE AND INCREASES AESTHETIC APPEAL
• 1/2" STANDARD BRASS NPT FLUIDLINE OUTLETS EASE PLUMBING CONNECTIONS.
• CORNERS ARE RIVETED TO INTERIOR ALUMINUM ANGLE BRACES FOR INCREASED STRUCTURAL INTEGRITY.
• AN ABS GASKET ISOLATES FLUIDLINE PASS-THROUGH.
• THE ABSORBER PLATE CONSISTS OF A COPPER FLOW TUBE MECHANICALLY EXPANDED INTO AN ALUMINUM WING. THIS PROVIDES SUPERIOR HEAT TRANSFER CHARACTERISTICS
• THE ABSORBER PLATE IS CHEMICALLY TREATED, COATED FLAT BLACK AND BAKED TO CREATE A DURABLE, HIGH PERFORMANCE SURFACE.
• STAINLESS STEEL NUTS AND BOLTS FASTEN THE BATTEN TO THE FRAMEWALL. SERVICING IS SIMPLIFIED BECAUSE COMPLETE ACCESS TO ALL COMPONENTS IS GAINED BY REMOVING FASTENERS.
• THE SILICONE GASKET PROVIDES A DURABLE U.V. RESISTANT SEAL.
• THE ALUMINUM BACKPLATE HELPS TO MAINTAIN THE RIGIDITY AND RUGGEDNESS OF THE PANEL.
• THE ALUMINUM EXTRUDED FRAMEWALL HAS BEEN DESIGNED FOR STRENGTH AND VERSATILITY WITH MOUNTING FLANGE AROUND THE PERIMETER.
• THE EXCLUSIVE ALUMINUM EXTRUDED HINGE MOUNTING SYSTEM HAS BEEN DESIGNED FOR QUICK AND SECURE INSTALLATIONS. THE HINGES MAY BE POSITIONED AT ANY POINT NECESSARY AROUND THE PERIMETER OF THE FRAMEWALL.

SPECIFICATIONS: CU30 FLAT PLATE SOLAR COLLECTOR

	CU30-SL	CU30-WW
UTSIDE DIMENSIONS:	98.5" x 48.5" x 2.57"	Same
PERTURE AREA (sq. ft.):	29.3	30.05
ERIMETER AREA	33.17	33.17
RY WEIGHT (lbs.):	156	190
OVER PLATE		
Material	Sheet Lime glass	Water White glass
Lights Per Panel	(3) 17 lbs. each	(1) 85.5 lbs.
Iron Oxide Content (5)	0.05	0.01
Thickness (inches)	1/8	3/16
Imensions (inches/light)	46 x 31.5	46 x 96
Solar Transmission (%)	84	91
Tensile Strength (psi)	6400 (tempered)	6400 (tempered)
Elastic Modules (psi 10^6)	10.5	10.5

OVER PLATE GASKET: Silicone gasket seal bonded to framewall and cover plate batten; UV stable

ACK PLATE

Material: 0.032 mill finish aluminum sheet

Weight: 13.0 lbs.

RAMEWALL, BATTEN, AND MULLION

Materials: aluminum alloy extrusion: Alloy no. 6063-T5

Weight: 35 lbs.

Finish: clear anodized

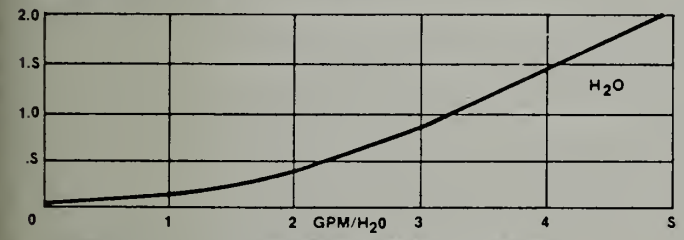
BSORBER PLATE

Material: 0.5" I.D. - 0.026 wall copper flow tubes mechanically expanded into extruded aluminum wings for superior thermal conductivity. Flow tubes brazed to ¾ inch copper headers unless specified otherwise. All wetted surfaces are copper or brass.

Fluid Capacity: 0.84 gallons

Flow Characteristics: 0.05 ft. head at 0.75 gpm flow rate (water). Internal baffles direct flow for a uniform flow distribution. Absorber plate is designed to allow for fluid drainage when used in freeze-dump systems. Maximum design flow rate is 5 gpm.

Pressure Drop Curve



THE ABOVE CURVE ILLUSTRATES PRESSURE DROP ACROSS THE CU30 PANEL WITH WATER AS THE TRANSFER FLUID.

Surface: Assembled plate is chemically treated and coated flat black unless specified otherwise.

Solar Absorptivity: 0.98

Emmissivity: 0.89

Weight: 49 lbs.

SULATION

Material: 1-1/8 inch isocyanurate foam board; routed to receive flow tube pattern.

Thermal Conductivity: 0.09 Btu-in./ft.^{2}°F

Flame Spread Classification: 20

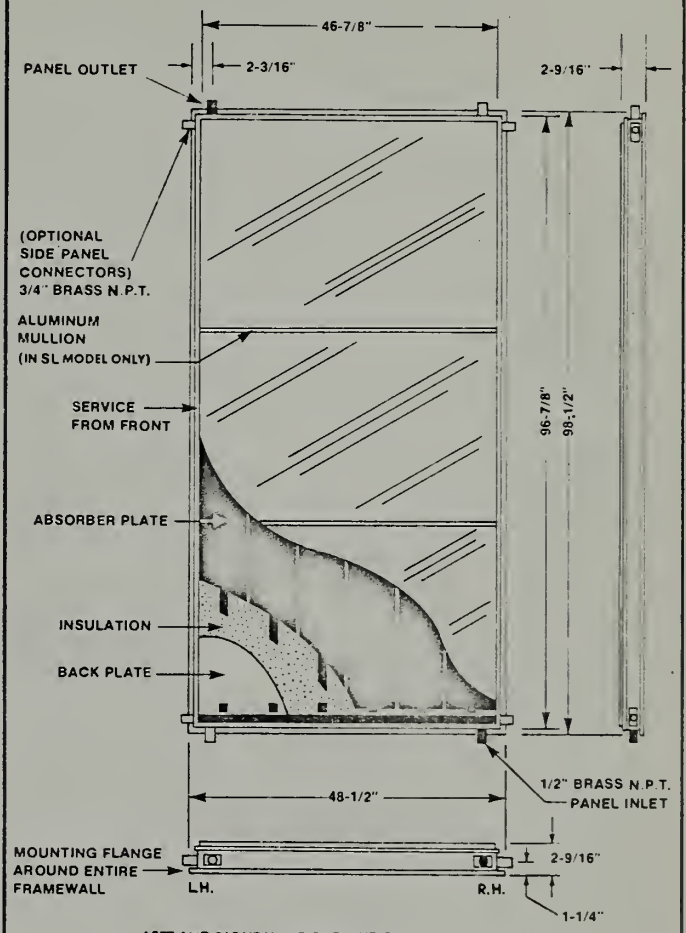
Weight: 7.0 lbs.

ESIGN LIFE: Material selection and design considerations allow an expected service life of thirty (30) years, when the panel is operated properly.

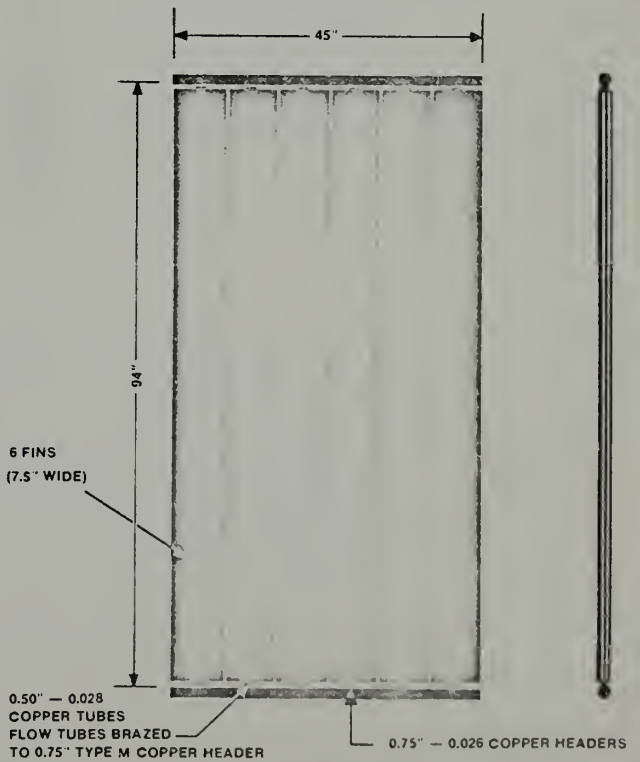
PTIONS

- **CU30-HRM Mounting System:** Aluminum extruded mill finish hinges (4) designed to mate with any section of framewall. Aluminum standoffs (2) and mounting brackets (4) suitable for fixed position or adjustable mounting (from 0° to 90°+). Weight 9.0 lbs.
- **CU30-SO** ¾" brass threaded outlets with parallel internal 1" I.D. — 0.035 wall copper headers.
- Left hand and right hand ½" brass NPT end outlets.
- **CN30 —** ½" cupronickel flow tubes for aggressive heat transfer fluids.

CU30-SL



LEFT AND RIGHT HAND END OUTLET OPTIONS AVAILABLE



ABSOPBER PLATE

APPENDIX E:

BASELINE COLLECTOR WARRANTY

THE CU30 SOLAR COLLECTOR PANEL LIMITED WARRANTY

A. Solar Energy Products, Inc., and Gulf Thermal Corporation warrant the Solar Energy Products, Inc.'s collector, including any component or assembly for a period of five years from date of installation against failure of the collector caused by a defect in materials or manufacture, but not glass breakage. This warranty covers the full cost of all parts, labor, shipping (to the site), handling (necessary to remedy defect), replacement at the site (if necessary), and field inspection (within a reasonable time of the complaint to verify failure, establish probable cause and determine corrective action required). This warranty goes with the collector and is unaffected by change of ownership as long as the collector remains in the original installation.

B. Solar Energy Products, Inc., and Gulf Thermal Corporation warrant the Solar Energy Products, Inc.'s collector absorber plate and coolant passages against failure due to corrosion when using Prestone II or equivalent heat exchange fluid for a period of five years from the date of installation. This warranty covers, for the first year only, the full cost of all parts (including the cost of furnishing a new collector), labor, shipping (to the site), handling (necessary to remedy the defect), replacement at the site (if necessary), and field inspection (within a reasonable time of the complaint to verify failure, establish probable cause and determine corrective action required). This warranty covers for the second through fifth years the full cost of all parts (including the cost of furnishing a new collector), labor and shipping to the site. The warranty goes with the collector and is unaffected by change of ownership as long as the collector remains in the original installation.

"Solar Energy Products, Inc., and Gulf Thermal Corporation warrant the Solar Energy Products, Inc.'s collector absorber plate and coolant passages against failure due to corrosion when using any copper compatible heat exchange fluid (as determined by the Copper Development Association) for a period of five years from the date of installation."

Volume III - Business Proposal

submitted to the

Department of Energy

by the

Airports Commission

of the city and county of

San Francisco, California

for

Solar Space and Water Heating

at

San Francisco International Airport

in response to

PON EG-78-N-01-4200

Volume III

BUSINESS PROPOSAL

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1. GENERAL INFORMATION DATA SHEETS

GENERAL BUSINESS INFORMATION

PROJECT PARTICIPANTS NAME & ADDRESS	CHECK AS APPROPRIATE					
	PUBLIC	PRIVATE	PROFIT	NON-PROFIT	TYPE BUSINESS LARGE	SMALL
a. Airports Commission of The City and County of San Francisco San Francisco Internat'l Airport San Francisco, CA 94128	X			X		
b. Interactive Resources, Inc. 117 Park Place Point Richmond, CA 94801		X	X			X
c. Gayner Engineers 821 Howard Street San Francisco, CA 94103		X	X			X

For each project participant, state whether a sole proprietor, partnership or corporation.

a. Local Government

b. Corporation

c. Corporation

CODE COMPLIANCE FORM A

1. Applicant Name and Address Airports Commission of The City and County of San Francisco, San Francisco International Airport, San Francisco, CA 94128

2. Building Location: San Francisco International Airport

   Building: Owned X Leased _____ Option _____

3. Building Use: Airport

   Building Permit: Pending _____ Approved _____ Not Submitted X

4. Building Construction: New X Modification _____

5. Building Codes: (check one)

   _____ complies with all governing codes

   X will comply with all governing codes, without substantive change from submitted description

   _____ has been granted approved by authorities having jurisdiction; waivers exceptions, or variances having been granted for features, or characteristics not in compliance with governing codes.

6. Based on Model Code: Yes X

   Name Uniform Building Code

   No _____

CODE COMPLIANCE FORM B

Category (identify project as Category "A" or "B". If "B", attach statement of explanation)

A

A. Compliance is measured against existing regulation, as documented, or with exceptions or variances not related to solar energy use.

B. Compliance is measured against exceptions or variances specifically related to solar energy use (attach statement of explanation

STATE OF COMPLIANCE (identify status of project as 1, 2, 3, or 4. Attach copies of supporting documents.)

3

1. Official document(s) of approval have been issued, covering land use, building size, location and orientation, landscape features, and building appearance (if control is legislated). Copy of approval document(s) attached. By signature below, Owner and Architect/Engineer affirm that project as submitted is in compliance with the approved documents.

2. By signature below, Owner and Architect/Engineer affirm that the project as submitted is in compliance with all applicable regulations. Affirmative statements by reviewing authorities, based on preliminary review, are attached.

   Example: "The project identified as (project title) has been reviewed for compliance with (regulations) and no conflicts with those regulations were apparent at the time of review. A final approval has not been issued because (documents incomplete, application not filed, fee not paid, further review required, review board convening date, other)."

3. By signature below, Owner and Architect/Engineer affirm that the project as submitted is, to the best of their knowledge, in compliance with all applicable regulations. No statement by a reviewing authority is attached, for the following reason(s):

   Check one:

   - [X] Project not submitted for review
   - [ ] Reviewing authority unwilling to make written statement
   - [ ] Other (attach statement of explanation)

4. The project requires or may require exception or variance from applicable regulations, and compliance cannot be affirmed.

Category	Status
A	3

Owner _____ Architect/Engineer _____ Reviewer _____

ASSURANCE OF COMPLIANCE WITH THE ENERGY RESEARCH
AND DEVELOPMENT REGULATION UNDER
TITLE VI OF THE CIVIL RIGHTS ACT OF 1964

Airports Commission of The
City and County of San Francisco (hereinafter called the "Applicant")
(Name of Applicant)

HEREBY AGREES THAT he/she will comply with title VI of the Civil Rights Act of 1964 (P.L. 88-352) and all requirements imposed by or pursuant to the Regulation of the Energy Research and Development Administration (10 CFR Part 4) issued pursuant to that title, to the end that, in accordance with title VI of that Act and the Regulation, no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefitsfits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant receives Federal financial assistance from the Energy Research and Development Administration; and HEREBY GIVES ASSURANCE THAT it will immediately take any measures necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of Federal financial assistance extended to the Applicant by the Energy Research and Development Administration, this assurance shall obligate the Applicant, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant for the period during which it retains ownership or possession of the property. In all other cases, this assurance shall obligate the Applicant for the period during which the Federal financial assistance is extended to it by the Energy Research and Development Administration.

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts or other Federal financial assistance extended after the date hereof to the Applicant by the Energy Research and Development Administration, including installment payments after such date on account of applications for Federal financial assistance which were approved before such date. The Applicant recognizes and agrees that such Federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the Applicant.

Dated 30 January 1978

Airports Commission of The
City and County of San Francisco
(Applicant)

By _____
(President, Chairman of Board, or comparable authorized official)

Richard R. Heath,
Director of Airports

San Francisco International Airport

San Francisco, CA 94128
(Applicant's mailing address)

P R O P O S A L

TO
DEPARTMENT OF ENERGY
OFFICE OF PROCUREMENT OPERATIONS
400 FIRST STREET, N.W.
WASHINGTON, D.C. 20545

1. IN RESPONSE TO PON	2. FOR (BRIEF DESCRIPTION)
NO. EG-78-N-01-4200 DATE & TIME PROPOSALS DUE: January 31, 1978; 4:30 PM	Third Cycle of Commercial Solar Heating and Cooling Demonstration Projects as part of the National Program for Solar Heating and Cooling of Buildings

3. THIS PROPOSAL CONSISTS OF THE FOLLOWING

(A) PROPOSAL PART NUMBERS AND DESCRIPTION	(B) NUMBER OF VOLUMES FOR EACH PART NO. (not # of copies)
PART I - PROJECT INFORMATION SUMMARY	1
PART II - TECHNICAL PROPOSAL	1
PART III - BUSINESS PROPOSAL, AND DATA/CODE COMPLIANCE FORMS	1
PART IV - COST PROPOSAL	1

4. TOTAL PROPOSED ESTIMATED PROJECT COST:

CONTRACTOR'S SHARE:	$161,750
DOE'S SHARE	$485,250

5. ACCEPTANCE PERIOD

THE UNDERSIGNED OFFERS AND AGREES, IF THIS OFFER IS ACCEPTED WITHIN 180 CALENDAR DAYS FROM THE DATE DESIGNATED FOR RECEIPT OF OFFERS, TO FURNISH THE ITEMS AND/OR SERVICES IN ACCORDANCE WITH PON ATTACHMENTS AND THIS PROPOSAL AT THE PRICE (OR ESTIMATED COST) STATED.

6. OFFEROR'S NAME, ADDRESS AND TELEPHONE NUMBER	7. NAME & TITLE OF PERSON AUTHORIZED TO SIGN (TYPE OR PRINT)*
NAME: Airports Commission of The City and County of San Francisco STREET: San Francisco International Airport CITY, COUNTY, San Francisco, San Francisco CITY, COUNTY STATE & ZIP CODE, San Francisco, San Francisco, CA 94128 AREA CODE & TELEPHONE NO.: (415) 876-2224	8. SIGNATURE Richard R. Heath, Director of Airports 9. DATE OF OFFER 30 January 1978

*The person signing the Proposal Form must have the authority to commit the offeror to all of the provisions of the proposal, fully recognizing that the Government has the right by terms of this PON to make an award without further discussion if it so elects.

2. Commitment

Authority of the Airport to install and operate the solar system is evidenced by their letter in Appendix A. Project commitment of the solar system designers is evidenced by letters from Dale Sartor, Director of Energy Systems for Interactive Resources, Inc. and Grant Wong, Associate Mechanical Engineer for Gayner Engineers.

3. Teaming Arrangements and Organization

Figure 3.1 summarizes the proposed team members, their project functions, project contacts, type of business and status and types of agreement.

In February 1978, architects will be selected to prepare contract documents for the proposed building. Their work will begin immediately thereafter. Solar system requirements developed by the solar system consultants will be integrated into the project by the architects and their professional consultants.

4. Project Experience

4.1 Airports Commission of the City and County of San Francisco. The Airports Commission and its staff have many years of experience executing multi-million dollar construction contracts. In-house departments include architecture, planning, structural, mechanical and electrical engineering, and construction management. Each department is staffed by qualified, registered professionals who review the design and construction of all Airport facilities for compliance with applicable codes and the functional requirements of the Airport's users and tenants.

4.2 Interactive Resources, Inc.

a. Organization and Objectives. Interactive Resources, Inc., is a California Corporation founded in 1973 to provide comprehensive professional services related to building design and construction. The firm includes four highly inter-related divisions: architecture and planning; structural engineering; energy management; and construction management. Each of these divisions provides a variety of consulting services to outside design firms as well as undertaking complete projects in-house.

b. Personnel. Interactive Resources, Inc. has a full-time professional staff of 18 which includes three registered architects, two registered mechanical engineers, two registered civil engineers, one registered structural engineer, and two licensed general building contractors.

c. Energy Management Services. In addition to normal comprehensive services in the field of building and environmental planning, Interactive

Figure 3.1

PROJECT IMPLEMENTATION TEAM

Teaming Arrangements

Team Member	Project Function	Project Contact	Type of Business	Status and Type of Agreement
Airports Commission of The City and County of San Francisco San Francisco International Airport San Francisco, CA 94128	Owner and Proposer (Administrative Program Manager)	Robert G. Lee Deputy Director and Chief Engineer (415)876-2224	Local Government non-profit	Commitment Letter
Interactive Resources, Inc. 117 Park Place Point Richmond, CA 94801	Solar System Designer (Technical Program Manager)	Dale Sartor Director of Energy Systems (415)236-7435	Private profit small	Contract for Professional Services
Gayner Engineers 821 Howard Street San Francisco, CA 94103	Consulting Mechanical & Electrical Engineers	Grant Wong Associate Mechanical Engineer (415) 398-1303	Private profit small	Subcontract for Professional Services

Resources, Inc. has developed a particular capability in energy-efficient design, alternative energy applications for buildings, and energy conservation planning.

d. Design and Implementation. Interactive Resources, Inc. has provided services successfully to a wide variety of public agency clients, including the cities of Richmond, San Jose, Davis and San Francisco; the County of Contra Costa; the Oakland Unified School District and the Santa Cruz City Schools; the State of California Office of the State Architect, the Energy Resources Conservation and Development Commission, and the California Conservation Corps; and (under subcontract) to the Department of Housing and Urban Development (HUD) and the Energy Research and Development Administration (ERDA, now the Department of Energy). They have worked with and understand the needs and functions of staff members and advisory groups. They have provided feasibility and design services for dozens of solar projects throughout northern California, many of which are now complete or under construction.

e. Research and Testing. The Interactive Resources, Inc. staff has developed an extensive resources library and maintains a communications network with others working in the energy field. A facility is maintained to test the performance of flat plate solar collectors, and a 6,000-watt wind generator was installed in conjunction with PGandE to test alternate electrical storage modes, control equipment and utility grid interface methods. These test facilities also serve as demonstrations for clients and students.

f. Education. Limited public knowledge of alternatives and widespread advertising of conventional energy systems impede the mass acceptance of solar heating for buildings. With a continuing commitment to publicizing opportunities for environmental enhancement and preservation through a sound energy policy, Interactive Resources, Inc. staff members have taken a leading educational role in energy conservation and solar energy applications for buildings. Over 1,000 students have received instruction from the Interactive Resources, Inc. staff at the College of Marin, Cogswell College, Heliotrope University, the Open Education Exchange, and the annual Solar Energy Applications in Buildings Conference at the Oakland Museum. Hundreds of others have heard Interactive Resources, Inc., staff speak to educational, professional, civic and fraternal organizations at classes and dinner meetings.

Under contract with the California Energy Resources Conservation and Development Commission, Interactive Resources, Inc. authored California Sunshine, A Consumer Guide to Solar Energy.

g. Energy Conservation Planning. The staff of Interactive Resources, Inc. is experienced in writing the energy conservation elements of Environmental Impact Reports, life-cycle costing analyses, and feasibility studies for energy conservation measures. The Energy Resources and Conservation Study for Contra Costa County was a typical project that involved preparation of two volumes, Energy Conservation Analysis and Recommendations for Contra Costa County, and Energy Conservation Guidelines for Evaluating New Development in Contra Costa County, and consultant input for a third volume, Energy Use and Conservation in Contra Costa County. They have extensive experience in evaluating and upgrading energy efficiency of tract housing developments, and commercial and public buildings.

h. Computer Capability. Interactive Resources, Inc. has an account at the University of California, Berkeley, Computer Center, and has access to FCHART, SOLCOST, CAL/ERDA and other programs which are critical for system simulation and optimization.

i. Experience and Staff Qualifications. A summary of relevant project experience is included in Appendix B and a summary of key staff qualifications in Appendix D.

4.3 Gayner Engineers.

a. Organization. Gayner Engineers is a California Corporation founded in 1941 to provide mechanical, electrical and plumbing designs for all types of commercial buildings.

b. Personnel. Gayner Engineers has a full-time professional staff of 11 which includes three electrical engineers, four mechanical engineers and one sanitary engineer.

c. Project Implementation. Gayner Engineers has provided services successfully to a wide variety of public agency clients including the Corps of Engineers, the University of California, Merritt Junior College, the State of California and the City of San Francisco. Their work encompasses the full range of project engineering services from the early conceptual design stages through construction to ensure their systems operate smoothly and efficiently.

d. Experience and Staff Qualifications. A summary of relevant project experience is included in Appendix C and a summary of key staff qualifications in Appendix D.

5. Key Personnel

Brief biographies and experience of the technical program manager and key personnel associated with the project are included in Appendix D.

6. Management Controls

The Airports Commission of the City and County of San Francisco will exercise management and fiscal control over the project utilizing existing in-house account procedures.

Cost and scheduling control has been established early during the conceptual stages of the project. An initial budget has been established and will be monitored through the remaining design stages by all project team members.

During construction, the Airports Commission staff will inspect all work to ensure that it is properly performed before payments are issued. In addition, the project professional consultants will periodically inspect the work and report to the owner on the quality of work performed and compliance with the construction documents as well as assisting the contractors with problems which might arise.

7. Financial Capability

The San Francisco International Airport operates on a completely self-sustaining basis. Since 1957 a total of some $54 million has been invested in the Airport for reconstruction and replacement of worn out facilities, equipment replacement needs and capital improvements. Continued self-sufficient operation of San Francisco International Airport has been a paramount factor in formulating the financial plan for the Airport expansion program.

In addition to 1967 general oblication bonds and 1975 revenue bonds, San Francisco voters approved a $90 million bond issue to November 1977 to finance the construction of the Airport's Modernization and Replacement Phase which includes the proposed project. Airport revenues, federal aid and interest on uncommitted funds will augment the bond funds required to complete the proposed project.

8. Industrial Stimulation

Completion of the Modernization and Replacement Phase will enable San Francisco International Airport to handle 31 million passengers each year. Few applications have the opportunity to provide solar heating for so many people. As a public institution, the Airport solar project is sure to receive close scrutiny from the San Francisco Bay Area newspapers, radio,

and television stations. With such visibility, a successful solar demonstration project undertaken by the City and County of San Francisco would carry a high degree of credibility and would be taken seriously by existing and potential energy customers.

It is of particular significance that the installation is to be made at the International Terminal. The United States has recently come under world-wide scrutiny and some criticism due to its high level of energy consumption and difficulties in establishing a firm energy policy. This installation could demonstrate to foreign visitors that there is a growing national commitment to energy conservation and the development of alternative energy sources.

The Airport is at the hub of an area devoted to commerce and light industry in the San Francisco Bay Area, which consists of nine counties. The San Francisco Peninsula, where the Airport is located, is recognized as one of the world's centers of innovative technology and scientific research.

The proposed solar system is a pilot project which, if successful, will lead to additional solar applications throughout the Airport complex. To be deemed successful, the project should demonstrate operational dependability and investment returns comparable to other alternatives as well as indirect social benefits.

The San Francisco Progress

Sunday, Nov. 6, 1977

Airport may go to solar power

By Marc Elliot

The use of solar energy may not be far off for San Francisco International Airport.

A nine-month study of the applicability of solar energy at the airport was conducted. Last week the Airports Commission heard the results.

Dale Sarto of Interactive Resources, Inc., the consulting firm that made the study told the commission that for about $600,000 the airport could install a pilot project. It would provide hot water and supplemental space heating for Rotunda A and Piers H and I.

Sartor estimated the project would allow the airport to reduce its energy consumption in these areas by more than 33 per cent. He also said it would pay for itself in 25 years even if the airport had to bear the whole cost.

Sartor said, however, that about 80 to 90 per cent of the installation cost was available from the federal government through the Energy Research and Development Administration.

He recommended that the airport apply for this funding as soon as possible. The deadline for applications is Jan. 1, 1978.

Sartor said that if the financing for the combined system was not available, a solar water heating unit alone could be installed for about $227,000.

A solar heating system works by absorbing the sun's rays. Direct use of sun energy is limited by darkness and cloudy weather.

To get around the inconsistent periods of sunshine, the energy must be stored. The easiest storage medium is water.

The system proposed for the airport is to mount on the roof a series of black metal plates with tubing embedded in them.

By insulating behind the plates and covering the plates with glass on the sun side, all the warmth is trapped in the plate.

"The temperature on the surface of these plates can reach 300 degrees," said Sartor.

Water pumped through the tubes and into a large tank provides the storage medium for the energy. The water can then be used as hot water or run through a heating coil in an air duct for space heating.

There are more elaborate systems: steam from solar-heated water to drive a generator and solar cells producing electricity for storage in batteries. Sartor recommended against such systems as being too costly and still in the experimental stages.

The one concern over the use of solar heating panels was the possibility of interferance with radar or distraction of control tower operators by reflection from the energy collectors.

Sartor said the Federal Aviation Authority did not express any major concern but would review any specific application the airport would make for the installation of a solar energy system.

The Interactive Resources report also listed eight immediate energy conservation measures which could be implemented to save the airport thousands of dollars a year. Most of the procedures would cost very little, it said.

For example, by operating the interior light switches with a light sensitive cell, and reducing the day - time light level, the airport could save $10,000 a year. The one - time cost of the photo - switches would be about $3,500.

Other possible economies cited were:

- Expanding the comfort range of heating and air conditioning from a constant 72 to a range of 65 to 80;
- Controlling garage exhaust fans by carbon monoxide monitors, they now operate continuously;
- Placing water flow restrictors in all the restrooms;
- Reducing the temprature of hot water from 140 degrees;
- Reducing window size in future additions, from 10 feet high to a four or five feet, with windows above floor level;
- Replacing bulbs and fluorescent ballasts, when they burn out, with lower wattage bulbs and more efficient ballasts.

The commission asked its staff to report back at the next meeting on how many of the energy conservation measures could be implemented immediately.

The commission also asked for further cost estimates on the installation of the suggested pilot program. These estimates are to be presented at the commission's Nov. 15 meeting for possible action.

Solar power at the airport?

APPENDIX A:

LETTERS OF COMMITMENT

AIRPORTS COMMISSION
CITY AND COUNTY OF SAN FRANCISCO
GEORGE R. MOSCONE, MAYOR

SAN FRANCISCO INTERNATIONAL AIRPORT
SAN FRANCISCO, CALIFORNIA 94128
(415) 761-0800

MORRIS BERNSTEIN
PRESIDENT
RUTH S. KADISH
VICE-PRESIDENT
WILLIAM E. McDONNELL
WILLIAM K. COBLENTZ

RICHARD R. HEATH
DIRECTOR OF AIRPORTS

January 26, 1978

U.S. Department of Energy
Operations, Division of Procurement
400 First Street, N.W., Room 206
Washington, D.S. 20545

Attention: James A. Ajello

Dear Mr. Ajello:

Subject: PON EG-78-N-01-4200, Commerical Integrated Project for Use in Demonstrations of Solar Heating and Cooling

The Airports Commission of the City and County of San Francisco is pleased to declare its intent and commitment to install and operate the Solar Energy System described in the attached proposal.

Very truly yours,

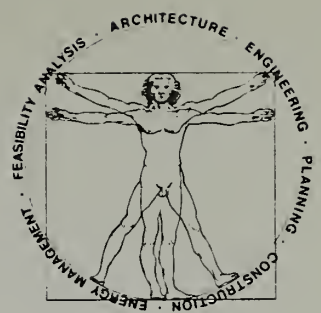
Richard R. Heath

RICHARD R. HEATH
Director of Airports

Interactive Resources, inc.
comprehensive professional services group

Thomas K. Butt, AIA
John E. Clinton, AIA SE
Dale A. Sartor
James C. Beavers
Charles L. Beavers
Carlos D. Garza
Suzanne E. Bean
Shirley R. Butt
Thomas N. Campiglia

Edward C. Love
Carl H. Bovill
E. Burr Nash
F. Thomas Collins, CE ME
George R. Teiber
Margie Tims
Karen M. Fee
John L. Peterson, ME



26 January 1978

Robert G. Lee, Deputy Director
and Chief Engineer
Airports Commission
City and County of San Francisco
San Francisco International Airport
San Francisco, CA 94128

Dear Mr. Lee:

Interactive Resources, Inc., is grateful to have been selected to provide solar engineering services for the South Terminal West Addition.

We are committed to provide additional professional services in accordance with the cost and scheduling portion of the proposal.

Sincerely,

INTERACTIVE RESOURCES, INC.

CHARLES BEAVERS
Charles L. Beavers

CLB/sb

117 park place point richmond, ca. 94801 (415)236-7435

GAYNER
ENGINEERS
321 HOWARD STREET
SAN FRANCISCO, CALIF. 94103
TELEPHONE: 415-398-1303

January 27, 1978
File No. 2484

Mr. R. G. Lee
Deputy Director and Chief Engineer
Airports Commission
P. O. Box 8097,
San Francisco International Airport
San Francisco, California 94128

Subject: Solar Energy Interphase
Connector to Rotunda "A" and
New South Terminal Extension

Dear Mr. Lee:

Gayner Engineers is pleased to be working as a team member with Interactive Resources Inc., (IRI) for the subject project.

We have worked closely with IRI on the Solar Energy Feasibility Study for the Airport. Our engineers have had practical experience in solar heating interphase projects in recent years.

We look forward to working with your staff in providing an energy efficient and environmentally pleasant facility.

Very truly yours,

GAYNER ENGINEERS

Grant Wong

GW:jb

DUANE M. HANSON LLOYD B. BYRON ROGER T. LEFLER ROCKNE LUNA PHILIP T. WONG
GRANT Y. L. WONG RONALD D. ZEIGER SILVAN P. PETERMANS SHIN-HWA HO

APPENDIX B:

PROJECT EXPERIENCE: INTERACTIVE RESOURCES, INC.

5 Work by Firm or Joint Venture Members which Best Illustrates Current Qualifications Relevant to this Project (List not more than 10 Projects)

Interactive Resources, Inc.

REPRESENTATIVE SOLAR ENERGY PROJECTS

a Project Name & Location	b Nature of Firm's Responsibility	c Owner's Name & Address	d Completion Date (actual or estimated)	e Estimated Cost (in thousands)	
				Entire Project	Work for which Firm was is responsible
Photographic Laboratory Mill Valley, Ca. (ERDA Cycle 1 Grant)	Design, Engineering & Construction Management	Iris Images, Inc. 16 Madrona Street Mill Valley, Ca. 94941	1976	130	130
Kaiser Permanente Medical Center San Rafael, Ca.	Solar System Design & Engineering	Kaiser Center 1924 Broadway Oakland, Ca. 94612	1978	80	80
California Maritime Academy Solar Applications Vallejo, Ca.	Solar System Design & Engineering	Office of State Architect State of California Sacramento, Ca. 95814	1978	250	250
San Francisco International Airport Solar Feasibility Study	Prime Consultant for Solar Feasibility Study	Airports Commission S.F. Int'l Airport San Francisco, Ca. 94128	1977	36	36
Stanford Food Services Bldg. Stanford University (ERDA Cycle 2 Grant)	Solar System Design & Engineering	Stanford University Stanford, Ca. 94305	1978	60	60
Residential Demonstration (HUD Cycle 2 Grant)	Solar System Design & Engineering	Mendocino Coast Properties Manchester, Ca.	1977	10	10
Turkel Residence Solar Assisted Heat Pump Santa Rosa, Ca.	Solar Consultant (Retrofit)	Doris Turkel 1575 Laguna Road Santa Rosa, Ca. 95401	1976	unknown	
Solar Swimming Pool Heating Davis Municipal Pools	Design & Engineering	City of Davis Davis, Ca.	1978	60	60
Woodlands Inn Solar Project Woodlands, Texas (ERDA Demonstration Grant)	Solar Design, Engineering & Construction Management	Mitchell Energy & Development Corporation The Woodlands, Texas	1978	350	350
10 Northern California Highway Patrol Stations	Solar & Energy Conservation Design & Engineering	Office of State Architect State of California Sacramento, Ca. 95814	1/78	360	360

g. Work by Firm or Joint Venture Members which Best Illustrates Current Qualifications Relevant to this Project (List not more than 10 Projects)					
a. Project Name & Location	b. Nature of Firm's Responsibility	c. Owner's Name & Address	d. Completion Date (actual or estimated)	e. Estimated Cost (in thousands)	
				Entire Project	Work for which Firm was/is responsible
Solar Retrofit for Personnel Building Sacramento, CA	Solar Design and Engineering	State of California Sacramento, CA	1978	20	20
Active and Passive Solar Applications: Fanslow Res. Sebastopol, CA	Project Design and Engineering	George Fanslow Sebastopol, CA	1977	60	60
Active and Passive Solar Applications: Roudebush Res Sausalito, CA	Project Design and Engineering	Bruce Roudebush 86 Prospect Sausalito, CA 94965	1978	200	200
Active and Passive Solar Applications: Goode Res. Sonoma, CA	Project Design and Engineering	Marilyn Goode 2303 Grove Street Sonoma, CA 95476	1976	75	75
Active and Passive Solar Applications: Castillo Res. Pittsburg, CA	Project Design and Engineering	Ed Castillo Pittsburg, CA 94565	1978	100	100
Passive Solar Applications: Niehuser Residence Occidental, CA	Project Design and Engineering	Richard Niehuser Occidental, CA	1976	40	40

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g. Work by Firm or Joint Venture Members which Best Illustrates Current Qualifications Relevant to this Project (List not more than 10 Projects)					
a. Project Name & Location	b. Nature of Firm's Responsibility	c. Owner's Name & Address	d. Completion Date (actual or estimated)	e. Estimated Cost (in thousands)	
				Entire Project	Work for which Firm was is responsible
Active and Passive Solar Applications Residential Retrofit Demonstration Project	Design, Engineering and HUD Grant Proposal Preparation	Oakland Unified School District Oakland, CA	1978	128	128
La Villa Condominiums (138 Residential Units) Antioch, CA	Project Design and Engineering, HUD Proposal Preparation	La Villa Investment Group Antioch, CA	1978	4,000	4,000
6 KW Wind Power Test Facility Point Richmond, CA	Design, Construction and Operation	Interactive Resources, Inc. 117 Park Place Point Richmond, CA 94801	1976	32	12
City of Richmond Government Service Center Richmond, CA	Project Design and Engineering, Active and Passive Solar Applic.	City of Richmond Richmond, CA	1978	5,500	5,500
One Hour Martinizing(laundry) Solar Demonstration Project Bakersfield, CA	Solar System Design and Engineering	PG&E 77 Beale Street San Francisco, CA 94105	1978	50	50
Solar Pool Heating Harbor High School Santa Cruz, CA	Solar System Design and Engineering	Santa Cruz Schools 133 Mission Street Santa Cruz, CA 95060	1978	60	60
Solar Heating Pacific School of Religion Berkeley, CA	Solar System Design and Engineering, DOE Grant Proposal	Pacific School of Religion 1798 Scenic Avenue Berkeley, CA	1978	20	20
Administration Building Solar Heating Livermore, CA	Solar System Design and Engineering, DOE Grant Proposal	City of Livermore Livermore, CA	1978	1,270	115
HUD Solar Demonstration Projects Technical Support	Sub-contractor for collection of Data	HUD and AIA Research Corporation	NA	continuing	continuing
Solar Heating for Bachelor Enlisted Quarters Mather AFB, CA	Solar Consultant for Feasibility Study	Department of the Army Corps of Engineers Sacramento, CA	NA	NA	NA

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8. Work by Firm or Joint Venture Members which Best Illustrates Current Qualifications Relevant to this Project (List not more than 10 Projects)

Interactive Resources, Inc.

REPRESENTATIVE EDUCATION AND PUBLISHING PROJECTS

a. Project Name & Location	b. Nature of Firm's Responsibility	c. Owner's Name & Address	d. Completion Date (actual or estimated)	e. Estimated Cost (in thousands) Entire Project	Work for which Firm was/is responsible
The Working Woodburner (38-page book)	Author (Dennis Dahlin) and Publisher	Interactive Resources, Inc. Point Richmond, CA	6/76	5	5
California Sunshine: A Consumer Guide to Solar Energy	Prime Consultant and Author	State of California Energy Resources Conservation and Development Commission	7/76	15	5
Solar Applications for Buildings Conference Oakland, CA	Conference Coordinator	Interactive Resources, Inc. Point Richmond, CA	7/75	12	12
Solar Applications for Buildings Conference Oakland, CA	Conference Coordinator	Interactive Resources, Inc. Point Richmond, CA	7/76	14	14
Solar Energy Applications Energy Efficient Design College of Marin, CA	Course Coordinator and Instructor (seven quarters)	College of Marin Kentfield, CA	1975-1977	N/A	N/A
Solar Energy Applications Energy Efficient Design Cogswell College, S.F.	Course Coprdinator and Instructor (two quarters)	Cogswell College San Francisco, CA	1976-1977	N/A	N/A
Solar Energy Applications Energy Efficient Design Open Education Exchange	Course Coordinator and Instructor (12 sessions)	Open Education Exchange Oakland, CA	1976-1977	N/A	N/A
Solar Applications for Building Conference Oakland, Ca.	Conference Coordinator	Interactive Resources, Inc. Point Richmond, Ca.	9/77	11	11

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8. Work by Firm or Joint Venture Members which Best Illustrates Current Qualifications Relevant to this Project (List not more than 10 Projects)

Interactive Resources, Inc.

REPRESENTATIVE ENERGY CONSERVATION PLANNING PROJECTS

a. Project Name & Location	b. Nature of Firm's Responsibility	c. Owner's Name & Address	d. Completion Date (actual or estimated)	e. Estimated Cost (in thousands) Entire Project	Work for which Firm was/is responsible
Contra Costa County Energy Resources and Conservation Study	Prepared EIR Energy Element Guidelines and Public Bldg. Analysis	Contra Costa County Planning Department Martinez, CA	6/76	25	15
Contra Costa County Criminal Justice Detention Facility	EIR Energy Conservation Element	Contra Costa County Martinez, CA	12/76	20,000	3.5
Hidden Lakes No. 3 (305 residential units) Martinez, CA	EIR Energy Element and Conservation Recommendations	Security Owners Corp. Martinez, CA	3/77	20,000	112
Alhambra Hills Subdivision (120 residential units) Martinez, CA	Energy Conservation Design Review	City of Martinez (client) Martinez, CA	4/77	6,000	.6
California Department of Motor Vehicles Building Santa Rosa, CA	Energy Conservation Consultant to Roland/Miller/Assoc.	State of California Dept. of Motor Vehicles Sacramento, CA	1978	1,000	.5

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APPENDIX C:

GAYNER ENGINEERS

	Code	Projects	(in thousands)		Code	Projects	(in thousands)		Code	Projects	(in thousands)
	043	100	600	11)	006	6	80	21)	010	2	20
	080	80	400	12)	076	15	40	22)	050	3	30
	061	100	200	13)	034	3	30	23)	045	2	60
	036	40	150	14)	039	3	80	24)	094	3	20
	062	40	100	15)	060	3	40	25)	082	3	10
	017	15	80	16)	072	3	40	26)	103	1	5
	058	10	80	17)	089	20	40	27)	098	1	2
	029	8	60	18)	027	5	35	28)	035	2	22
	032	8	60	19)	100	3	35	29)	048	1	11
	008	4	50	20)	057	2	100	30)			

11. Project Examples, Last 5 Years

Profile Code	"P", "C", "JV", or "IE"	Project Name and Location	Owner Name and Address	Cost of Work (in thousands)	Completion Date (Actual or Estimated)
043	C	1 IBM West Coast Programming Development Center San Jose, CA	IBM Monterey and Cottle Roads San Jose, CA 95913	5,500	1975
080	C	2 Yerba Buena Center Public Sector San Francisco, CA	San Francisco Redevelopment Agency 939 Ellis St., P.O. Box 646 San Francisco, CA 94101	2,500	1974
061	C	3 Hayward Hall of Justice Hayward, CA	Alameda County Alameda County Government Center Amador St., Hayward, CA	750	1974
036	C	4 Yerba Buena Center Public Sector San Francisco, CA	San Francisco Redevelopment Agency 939 Ellis St., P.O. Box 646 San Francisco, CA 94101	1,800	1974
062	P	5 Aircraft Maintenance Area Lighting Travis AFB, CA	Western Division Naval Facilities Engineering Command San Bruno, CA 94066	1,000	1976
017	C	6 Stanford Shopping Center Stanford, CA	Stanford University 100 Encine Hall Stanford, CA 94035	1,500	1976
058	C	7 Naval Biomedical Research Laboratory Alameda, CA	West. Div. NFEC San Bruno, CA 94066	91	1974

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		Oakland, CA	Oakland, CA 94610		
032	P	1587 Franklin Street, Oakland, CA	Pacific Telephone & Telegraph 44 Montgomery St., San Francisco, CA	(Study) 10	1976
008	C	10 American Conservatory Theater San Francisco, CA	ACT 401 Geary Street, San Francisco, CA	226	1974
006	C	11 Garage Stage V Final Modifications, San Francisco International Airport, SF, CA 94128	San Francisco Airport Commission San Francisco International Airport San Francisco, CA 94128	2,500	
076	C	12 Pacific Telephone & Telegraph Santa Clara, CA	Pacific Telephone & Telegraph 4 North 2nd St., San Jose, CA 95113	350	1972
034	C	13 Oakhill Underground Radio Relay Station San Jose, CA	Pacific Telephone & Telegraph 4 North 2nd St., San Jose, CA 95113	308	1974
039	C	14 Yerba Buena Center Public Sector Garage San Francisco, CA	San Francisco Redevelopment Agency 939 Ellis St., P.O. Box 646 San Francisco, CA 94101	1,800	1972
060	C	15 Merritt College Library Oakland, CA	Peralta Community College District 300 Grand Avenue, Oakland, CA 94610	198	1973
072	C	16 Pacific Telephone & Telegraph PSC Building San Leandro, CA	Pacific Telephone & Telegraph 44 Montgomery Street San Francisco, CA	170	1974
089	P	17 Southern Pacific Company 475 Brannan Street, San Francisco, CA	Southern Pacific Transportation No. 1 Market Street, San Francisco, CA	60	1974
027	C	18 Host International Commissary San Francisco, CA	Host International P.O. Box 1760; Pico at 34th St., Santa Monica, CA 90406	640	1975
100	C	19 Standard Oil Emission Laboratory Richmond, CA	Chevron Research Company 576 Standard Avenue, Richmond, CA 94802	61	1974

			Government Center Hayward, CA		
010	C	21 Sacramento State University Residence Halls & Dining Facilities, Sacramento, CA	Trustees of the California State Universities 6000 "J" St., Sacramento, CA	783	1972
050	C	22 Stanford Row Housing Stanford, CA	Stanford University 100 Encina Hall Stanford, CA 94035	468	1975
045	C	23 Pacific Telephone & Telegraph 611 Folsom St., San Francisco, CA	Pacific Telephone & Telegraph 44 Montgomery St., San Francisco, CA	1,800	1971
094	C	24 Yerba Buena Center Public Sector San Francisco, CA	San Francisco Redevelopment Center 939 Ellis Street, P.O. Box 846 San Francisco, CA 94101	875	1974
082	C	25 Martinez Post Office Martinez, CA	United States Postal Service Court Street Station Martinez, CA	35	1975
103	C	25 Merritt College Swimming Pool Oakland, CA	Peralta Community College District 300 Grand Avenue, Oakland, CA 94610	168	1975
098	C	27 University of California Gymnasium Santa Cruz, CA	Regents of the University of California Santa Cruz, CA 95064	110	1976
035	C	28 Alameda College Gymnasium Alameda, CA	Peralta Community College District 300 Grand Avenue, Oakland, CA 94612	442	1974
048	C	29 Children's Hospital Medical Office Building San Francisco, CA	Children's Hospital California at Cherry St., San Francisco, CA	500	1971
112	C	30 Pacific Telephone & Telegraph Plant Work Center Santa Cruz, CA	Pacific Telephone & Telegraph 4 North 2nd Street, San Jose, CA	45	1975

12. The foregoing is a statement of facts

Signature Duane M. Hanson Typed Name and Title: Duane M. Hanson - President

Date: June 23, 1977

Standard Form 254 July 1[illegible]

APPENDIX D:

BIOGRAPHIES AND EXPERIENCE OF KEY PERSONNEL

INTERACTIVE RESOURCES, INC.

Key Personnel

Thomas K. Butt, Environmental Architect

President of Interactive Resources, Inc., since 1973, Mr. Butt is an authority on energy-efficient building design and life-cycle costing techniques. He holds a Master of Architecture degree from UCLA and a Bachelor of Architecture and Bachelor of Arts degree from the University of Arkansas. Professional memberships include the American Institute of Architects, the National Association of Realtors, and the Northern California Solar Energy Association. Mr. Butt is a registered architect, licensed general building contractor, and licensed real estate broker. As project architect for the $5.5 million City of Richmond Government Service Center, he recently supervised completion of construction documents on a building with comprehensive active and solar applications designed to save up to 50 per cent of normal energy requirements.

Dale Sartor, Solar Engineer

Mr. Sartor is director of energy systems for Interactive Resources, Inc. A graduate of Architecture from the University of California, Berkeley, Mr. Sartor has distinguished himself as an educator, researcher, designer and professional activist in the field of energy conservation and alternative energy applications for buildings. He served as Chairman of the Energy Committee for the East Bay Chapter of the American Institute of Architects, and is a member of the executive board of the Northern California Solar Energy Association. Mr. Sartor heads the legislative subcommittee of the Golden Gate Chapter Solar Energy Committee of the American Society of Heating, Refrigerating and Air Conditioning Engineers. He also holds a teaching certificate for California Community Colleges and has taught solar energy courses at the College of Marin, Cogswell College and Heliotrope University since 1974. Mr. Sartor was project manager for the massive San Francisco International Airport Solar Feasibility Study.

Carl Bovill, Energy Conservation Engineer

Mr. Bovill received a Master of Architecture degree from the University of Hawaii and a Master of Science in Mechanical Engineering degree (thermal systems) from the University of California, Berkeley. In 1977 he collaborated in the publication of a book, Residential Energy Design in the State of Hawaii, and was involved in the thermal systems design, construction and analysis of the award winning Hawaiian Energy House Project at the University of Hawaii. Recent projects at Interactive Resources, Inc., include the San Francisco International Airport Solar Feasibility Study, the California Highway Patrol Energy Conservation Retrofit for 10 stations, and the City of Davis Swimming Pool Solar Retrofit.

GAYNER ENGINEERS

Key Personnel

Duane M. Hanson, Professional Engineer

As President of Gayner Engineers since 1957, Mr. Hanson has more than 20 years of design experience in all types of commercial and industrial projects. He holds a Bachelor of Science degree in Mechanical Engineering from the University of California at Berkeley. He is a registered Professional Engineer in California, Arizona, Washington, Utah and New Mexico.

Grant Wong, Associate Mechanical Engineer

Mr. Wong holds a Bachelor of Science degree in Mechanical Engineering from the University of California at Berkeley. He has many years of experience in the design and construction of mechanical systems. Several of his recent projects have included solar and energy conservation projects.

Volume IV - Cost Proposal

submitted to the

Department of Energy

by the

Airports Commission

of the city and county of

San Francisco, California

for

Solar Space and Water Heating

at

San Francisco International Airport

in response to

PON EG-78-N-01-4200

Appendix D
EXHIBIT 1

GENERAL INFORMATION

1. Proposing Organization: Airports Commission of the City & County of San Francisco

   Address: San Francisco International Airport

   San Francisco

   California 94128

2. Project Location: San Francisco, California

3. Type of Organization: Local government
   (State or Local government, corporation, non-profit, etc.)

4. Has your organization ever been audited by the Federal Government; Yes (Yes/No)

   If yes provide name, address, and telephone number of Federal Agency
   Airport Development Aid Program
   Federal Aviation Administration
   831 Mitten Road, Burlingame, CA 415/876-2775

5. If a State or Local government state whether an approved overhead rate is available for use in the proposed budget; yes (yes/no). If yes, provide the rate 40% and the name, address, and phone number of the approving agency.

   Airport Development Aid Program

   Federal Aviation Administration

   831 Mitten Road

   Burlingame, CA 415/876-2775

6. Describe your accounting system. Is it a Standard costing system, job order system, etc.?

   Project cost accounting

7. Describe the general costing approach and rational for the determination of the total projected incremental solar cost.

   (See p.3)

8. Include a discussion of the terms under which cost quotations were obtained and what cost guarantees were received concerning their validity past the assumed authority to proceed date.

   (See p.3)

9 . Include a general discussion of the economic analysis considered appropriate for the project.

(See p. 3)

10. Provide a list of all team members and the total budget for each;

NAME	AMOUNT
Airports Commission	$ 10,796
Professional Consultants	$ 80,452
Contractors (to be determined)	$ 555,758
	$

Total project budget* $ 647,000

less Amount to be cost shared $ 161,750

Total funds requested $ 485,250

* Total solar system installed cost per Exhibit 2, item E.

7. General Costing Approach

The building for which this solar system is proposed is presently in a schematic design phase. Although the system has been thoroughly developed, many assumptions have had to be made. Cost estimating has, therefore, relied largely on generalized estimating techniques developed by the system designer and professional consultants on solar projects of this scale, as well as on millions of dollars of non-solar work.

Estimates have been aided by material and quantity takeoffs, vendor quotes and historical data wherever possible.

In addition, estimates have been grounded on the knowledge that installing solar systems is still a new field with which many contractors are unfamiliar, a fact which can lead to increased profit, overhead, and contingency factors. The cost estimate for the project reflects this conservatism.

Construction is scheduled to begin in early 1979 and costs have been escalated to take this into account.

8. Cost Figures

With the considerations mentioned in Section 7 of this volume kept in mind, the solar designers have developed a complete system and made a realistic and conservative cost estimate. Because the building design is incomplete and will go to competitive bidding, it has not been possible to get contractor prices. However, the system designer is in the fortunate position of having designed a number of large solar installations. Several of these designs have been competitively bid. Further, the solar system designer maintains a construction management department, and a subsidiary contracting firm specializing in solar installations. This experience has enabled them to develop reference material and a cross-checking system resulting in cost estimates which have shown to be reasonably accurate; improvements are continually being made.

In response to the requirement for a "type of quote", the designers have made use of all the methods listed in the quote legend of the PON. The legend used in each line item represents the deciding factor, but is usually backed up by other factors.

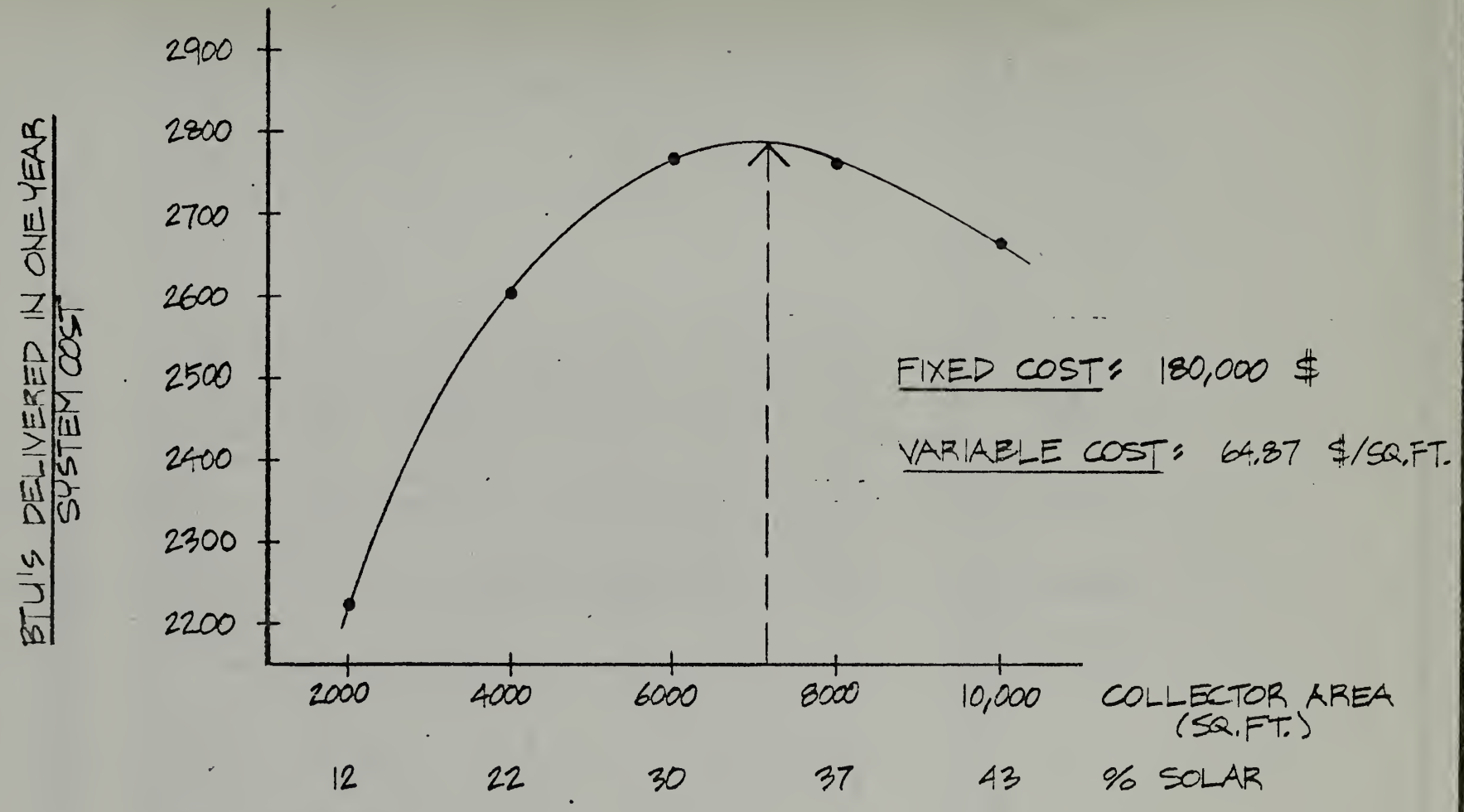
An escalation of one per cent per month, for a period of 12 months, has been added to the total present-day cost estimate to account for the 1979 start of construction.

9. Economic Analysis

FCHART computer simulations were run for a range of collector areas in order to find the collector size that would maximize the BTU's per dollar invested (see Figure 4.1).

Using a solar system with 7200 square feet of collector area and a system cost of $647,000, an FCHART solar simulation and life-cycle economic analysis was run. First year fuel costs were inflated to account for the system start-up in early 1981. The FCHART life-cycle analysis shows a 6.1 per cent internal rate of return over 30 years (see Figures 4.2, 4.3 and 4.4).

A sensitivity analysis of the solar system was run. System cost, fuel price increase, yearly maintenance costs, value of money and term of economic analysis were all varied to investigate the relative influence of each parameter on life-cycle value. The analysis showed the overwhelming influence of time on the economic value of the system, while the other parameters including initial cost, showed a relatively small impact on long-term value. This suggests that extra initial costs which add to the life of the system are well spent. In addition, a system that can survive the inevitable remodeling the Airport experiences would realize much greater returns.



san francisco international airport — solar heating proposal

fig. 4.1 system optimization

CODE	VARIABLE DESCRIPTION	VALUE	UNITS
1	AIR SYSTEM=1,LIQUID SYSTEM=2.....	2.00	
2	COLLECTOR AREA.....	7200.00	FT2
3	FRPRIME-TAU-ALPHA PRODUCT(NORMAL INCIDENCE)..	.79	
4	FRPRIME-UL PRODUCT.....	1.10	BTU/H-F-F2
5	NUMBER OF TRANSPARENT COVERS.....	1.00	
6	COLLECTOR SLOPE.....	35.00	DEGREES
7	AZIMUTH ANGLE (E.G. SOUTH=0, WEST=90).....	12.00	DEGREES
8	STORAGE CAPACITY.....	15.00	BTU/F-FT2
9	EFFECTIVE BUILDING UA.....	0.	BTU/HR-F
10	CONSTANT DAILY BLDG HEAT GENERATION.....	0.	BTU/DAY
11	(EPSILON)(CMIN)/(EFFECTIVE BUILDING UA).....	1.00	
12	HOT WATER USAGE.....	5192.00	GAL/DAY
13	WATER SET TEMPERATURE.....	105.00	F
14	WATER MAIN TEMPERATURE.....	57.00	F
15	CITY CALL NUMBER.....	137.00	
16	THERMAL PRINT OUT BY MONTH=1, BY YEAR=2.....	1.00	
17	ECONOMIC ANALYSIS < YES=1, NO=2.....	1.00	
18	USE OPTMZD. COLLECTOR AREA=1, SPECFD. AREA=2.	2.00	
19	SOLAR SYSTEM THERMAL PERFORMANCE DECRADATION.	0.	*/YR
20	PERIOD OF THE ECONOMIC ANALYSIS.....	30.00	YEARS
21	COLLECTOR AREA DEPENDENT SYSTEM COSTS.....	0.	$/FT2 COLL
22	CONSTANT SOLAR COSTS.....	647095.00	$
23	DOWN PAYMENT(* OF ORIGINAL INVESTMENT).....	100.00	*
24	ANNUAL INTEREST RATE ON MORTGAGE.....	0.	*
25	TERM OF MORTGAGE.....	1.00	YEARS
26	ANNUAL NOMINAL(MARKET) DISCOUNT RATE.....	5.00	*
27	EXTRA INSUR.,MAINT. IN YEAR 1(* OF ORIG.INV.)	1.00	*
28	ANNUAL * INCREASE IN ABOVE EXPENSES.....	7.00	*
29	PRESENT COST OF SOLAR BACKUP FUEL (BF).....	4.03	$/MMBTU
30	BF RISES */YR=1,SEQUENCE OF VALUES=2.....	1.00	
31	IF 1, WHAT IS THE ANNUAL RATE OF BF RISE.....	15.00	*
32	PRESENT COST OF CONVENTIONAL FUEL (CF).....	4.03	$/MMBTU
33	CF RISES */YR=1,SEQUENCE OF VALUES=2.....	1.00	
34	IF 1, WHAT IS THE ANNUAL RATE OF CF RISE.....	15.00	*
35	ECONOMIC PRINT OUT BY YEAR=1, CUMULATIVE=2...	1.00	
36	EFFECTIVE FEDERAL-STATE INCOME TAX RATE.....	0.	*
37	TRUE PROP. TAX RATE PER $ OF ORIGINAL INVEST.	0.	*
38	ANNUAL * INCREASE IN PROPERTY TAX RATE.....	0.	*
39	CALC.RT. OF RETURN ON SOLAR INVTMT<YES=1,NO=2	1.00	
40	SALVAGE VALUE (* OF ORIGINAL INVESTMENT).....	30.00	*
41	INCOME PRODUCING BUILDING< YES=1,NO=2.....	2.00	

san francisco international airport — solar heating proposal

fig. 4.2 fchart input data

SAN FRANCISCO . CA 37.47

****THERMAL ANALYSIS****

TIME	PERCENT SOLAR	INCIDENT SOLAR (MMBTU)	HEATING LOAD (MMBTU)	WATER LOAD (MMBTU)	DEGREE DAYS (F-DAY)	AMBIENT TEMP (F)
JAN	11.7	256.97	956.64	64.54	437.	50.
FEB	21.8	296.59	628.09	58.29	325.	54.
MAR	33.9	407.41	557.23	64.54	332.	54.
APR	46.0	421.05	392.96	62.46	291.	55.
MAY	70.2	436.68	202.92	64.54	257.	57.
JUN	88.6	414.71	106.29	62.46	194.	59.
JUL	92.8	397.22	74.08	64.54	202.	59.
AUG	92.9	384.23	67.64	64.54	177.	59.
SEP	98.5	381.64	51.54	62.46	102.	63.
OCT	65.7	369.48	177.15	64.54	127.	61.
NOV	26.5	288.65	460.71	62.46	233.	57.
DEC	13.1	240.33	753.71	64.54	403.	52.
YR	34.6	4294.98	4428.98	759.91	3060.	

san francisco international airport — solar heating proposal

fig. 4.3 — fchart thermal analysis

****ECONOMIC ANALYSIS****
SPECIFIED COLLECTOR AREA = 7200. FT2
INITIAL COST OF SOLAR SYSTEM = $ 647095.
THE ANNUAL MORTGAGE PAYMENT FOR 1 YEARS = $ 0.

YR	INTRST PAID	END OF YR PRINC	DEPRC DEDUCT	PROP TAX PAID	INC TAX SAVED	BACKUP FUEL COST	INSUR, MAINT COST	COST WITH SOLAR	SAVNGS WITH SOLAR	PW OF SOLAR SAVNGS
1	0	0	0	0	0	13678	6470	667244	-646334	-646370
2	0	0	0	0	0	15730	6923	22654	1393	1263
3	0	0	0	0	0	18090	7408	25498	2156	1852
4	0	0	0	0	0	20803	7927	28730	3072	2527
5	0	0	0	0	0	23924	8482	32406	4167	3265
6	0	0	0	0	0	27513	9075	36588	5471	4082
7	0	0	0	0	0	31639	9711	41351	7017	4987
8	0	0	0	0	0	36385	10390	46776	8847	5988
9	0	0	0	0	0	41843	11118	52962	11005	7094
10	0	0	0	0	0	48120	11896	60017	13546	8316
11	0	0	0	0	0	55338	12729	68067	16529	9664
12	0	0	0	0	0	63639	13620	77259	20027	11152
13	0	0	0	0	0	73185	14573	87758	24121	12792
14	0	0	0	0	0	84162	15593	99756	28905	14599
15	0	0	0	0	0	96787	16685	113472	34488	16589
16	0	0	0	0	0	111305	17853	129159	40996	18781
17	0	0	0	0	0	128001	19103	147104	48574	21193
18	0	0	0	0	0	147201	20440	167642	57389	23846
19	0	0	0	0	0	169281	21871	191153	67632	26764
20	0	0	0	0	0	194674	23402	218076	79527	29973
21	0	0	0	0	0	223875	25040	248915	93328	33499
22	0	0	0	0	0	257456	26793	284249	109331	37374
23	0	0	0	0	0	296074	28668	324743	127874	41632
24	0	0	0	0	0	340466	30675	371161	149349	46308
25	0	0	0	0	0	391558	32823	424382	174205	51443
26	0	0	0	0	0	450292	35120	485413	202962	57081
27	0	0	0	0	0	517836	37579	555415	236216	63270
28	0	0	0	0	0	595512	40209	635721	274655	70062
29	0	0	0	0	0	684839	43024	727863	319070	77516
30	0	0	0	0	0	787564	46036	839472	564501	130612

THE DISCOUNTED RATE OF RETURN ON THE SOLAR INVESTMENT(%)= 6.1
THE DISCOUNTED PAYBACK PERIOD IS(YR) 29.
YRS UNTIL CUMULATIVE SAVINGS=MORTGAGE PRINCIPLE 29.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH SOLAR = $ 2807293.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O SOLAR = $ 2994470.
PRESENT WORTH OF CUMULATIVE SOLAR SAVINGS = $ 187177.

san francisco international airport — solar heating proposal

fig. 4.4 fchart economic analysis

APPENDIX D
EXHIBIT 2

PROJECT COST DATA

PROPOSER Airports Commission of the City & County of San Francisco

PROJECT LOCATION San Francisco International Airport, San Francisco, CA 94128

A. SOLAR ENERGY SYSTEM COSTS (Material only)

o SOLAR COLLECTORS

		Type of Quote	Amount
1.	TOTAL AREA 7200 SQ. FT.		
2.	UNIT COST $ 12.20 PER SQ. FT.	(VQ)	
3.	COLLECTOR COST	(VQ)	$ 87,900.00
4.	SHIPPING & DELIVERY COST	(VQ)	$ 5,000.00
5.	TOTAL DELIVERED COST (A3 + A4)		$ 92,900.00

o ENERGY TRANSPORT

		Type of Quote	Quantity	x Unit Cost	=	Amount
6.	PIPING, VALVES, PUMPS, FILTERS	(MC)	Varies			$ 58,462.00
7.	HEAT TRANSFER FLUID (If Applicable)	( )				$ N/A
8.	HEAT EXCHANGER(S)	(VQ)	1 1	20,000 1,700		$ 21,700.00
9.	OTHER (Specify) Insulation	(VQ)	Varies			$ 11,496.00
10.	TOTAL COST OF ENERGY TRANSPORT (A6 through A9)					$ 91,658.00

o STORAGE

		Type of Quote	Quantity	x Unit Cost	=	Amount
			MC 1	$4050		
11.	STORAGE TANKS(S), FILTERS	(VE)	1	9760		$ 13,810.00
12.	STORAGE MEDIUM	( )				$ N/A
13.	INSULATION, LINING, FINISH	(PH)	3450 SF	.65		$ 2,243.00
14.	OTHER (Specify) _____	( )				$
15.	TOTAL COST OF STORAGE (A11 through A14)					$ 16,053.00

o SOLAR COOLING SYSTEM

16.	TYPE: _____	( )				$
17.	OTHER (Specify) _____	( )				$
18.	_____	( )				$
19.	TOTAL COST OF SOLAR COOLING SYSTEM (A16 through A18)					$ N/A

o CONTROLS & SAFETY DEVICES

20	CONTROLS	(MC)	Varies			$ 4,400.00
21.	SAFETY DEVICES (included in Controls)	( )				$
22.	OTHER (Specify) _____	( )				$
23.	TOTAL COST OF CONTROLS & SAFETY DEVICES (A20 through A22)					$ 4,400.00

APPENDIX D
EXHIBIT 2

o OTHER RELATED COSTS

	Type of Quote	Unit Quantity x Cost	=	Amount
24. OTHER SOLAR SYSTEM RELATED COSTS List and (Specify) Structural Support System	(EE)	N/A		$ 26,100.00
25. TOTAL OTHER SOLAR COSTS				$ 26,100.00

o TOTAL SOLAR SYSTEM COSTS

26. TOTAL SOLAR ENERGY SYSTEM COSTS (A5+A10+A15+A19+A23+A25)				$231,111.00

APPENDIX D
EXHIBIT 2

B. SOLAR SYSTEM DESIGN & INSTALLATION COSTS (labor only)

o DESIGN COST (A&E)

		Type of Quote	Labor hours	x	Labor Rate	=	Amount
1.	SCHEMATIC DESIGN PHASE	( )					$ 5,000.00
2.	DESIGN DEVELOPMENT PHASE	( )	Professional Fees				$ 24,590.00
3.	CONSTRUCTION DOCUMENT PHASE	( )					$ 16,657.00
4.	ON SITE SUPPORT	( )					$ 12,015.00
5.	OTHER (Specify) Project Administration - 2% of construction + design fees						$ 10,790.00
6.	TOTAL SYSTEM DESIGN COSTS (BI through B5)						$ 69,052.00

o INSTALLATION COSTS

7.	COLLECTOR INSTALLATION (i+ii)	(EE)	200 16		$30.00[1] 95.00	$ 7,500.00
	i) TRADE Plumbing (e.g., plumbing, ironwork, etc.)	$ 6,000.00				
	ii) TRADE Crane & Crew	$ 1,500.00				
8.	ENERGY TRANSPORT	(MC)	1281.6		$30.00	$ 38,448.00
9.	STORAGE	(MC)	Varies			$ 5,390.00
10.	SOLAR COOLING SYSTEM (incremental costs over conventional unit) _____	( )				$ N/A

[1]Includes 30% overhead and profit

APPENDIX D
EXHIBIT 2

		Type of Quote	Labor hours	x	Labor Rate	=	Amount
11.	CONTROLS & SAFETY DEVICES	(MC)	220		$30.00		$ 6,600.00
12.	STRUCTURAL & INSTALLATION COST	(MC)	Varies				$ 17,900.00
13	OTHER (Specify) Energy Transport Insulation	(MC)	536.5		$30.00		$ 16,094.00
14.	Storage Insulation	(MC)	8		$20.00		$ 160.00
15.	TOTAL INSTALLATION COST (B7 through B14)						$ 92,092.00
							$
16.	TOTAL DESIGN & INSTALLATION COSTS (B6 + B15)						$ 161,144.00

C. OTHER

1. MAINTENANCE MANUAL PREPARATION COST (includes maintenance personnel training) $ 5,000.00

2. OTHER PROJECT COST (List)

Contractors Bond (1%)	$ 4,644.00	Subcontractors' Profit & Overhead (30%)	$ 77,055.00
Interest	743.00	Taxes, Fees, Etc. (1%)	4,004.00
One Year Cost Escalation	66,030.00	General Contractor's Profit & Overhead (15%)	60,053.00
Contingency	30,814.00		
DOE Reporting Requirements	6,400.00		

3. TOTAL OTHER COST $ 254,743.00

APPENDIX D
EXHIBIT 2

D.	TOTAL COST OF SOLAR SYSTEM (A26 + B16)	$ 392,255.00
E.	TOTAL SOLAR PROJECT COST (D + C3)	$ 647,000.00
F.	TOTAL AMOUNT TO BE COST SHARED BY OFFEROR	$ 161,750.00
G.	TOTAL FUNDS REQUESTED (E less F)	$ 485,250.00

APPENDIX D
EXHIBIT 3

PROJECT COST DATA

A. SOLAR SYSTEM ANNUAL OPERATION & MAINTENANCE (O&M) COSTS

o SOLAR SYSTEM OPERATING COST

1. TYPE OF ENERGY CONSUMED electricity
e.g., gas, electricity, etc.

2. UNIT OF ENERGY CONSUMED kwh
e.g., cu. ft, kwh, etc.

3. ANNUAL SYSTEM OPERATING COST

0.03 $/kwh (rate per unit*) x 33,936 kwh (annual energy requirements) = $ 1,018 /yr

o BACK-UP ENERGY COST

4. TYPE OF ENERGY CONSUMED gas/oil Gas service is interrupted about 50% of the time
e.g., gas, electricity, etc.

5. UNIT OF ENERGY CONSUMED BTU x 10^6

6. ANNUAL BACK-UP ENERGY COST

3.43 $/$10^6$ BTU (rate per unit*) x 3,394 x 10^6 BTU (annual energy requirements) = $ 11,641 /yr

o OTHER SOLAR SYSTEM COSTS

7. ANNUAL MAINTENANCE COST, INSURANCE $ 5,452

8. INSURANCE & TAXES $ _____

9. OTHER (Specify) _____ $ _____

*Based on December 1977 rates.

APPENDIX D
EXHIBIT 3

PROJECT COST DATA

o TOTAL SOLAR SYSTEM O&M COSTS

10.	TOTAL ANNUAL O&M COSTS (A3+A6+A7+A8+A9)	$ 18,111

B. CONVENTIONAL SYSTEM ENERGY COSTS

1.	TYPE	Gas/Oil	Interruptable gas. Probable 50/50 gas/oil use.
2.	UNIT	10^6 BTU	
3.	ANNUAL FUEL COSTS*	$ 17,798	

C. SOLAR SYSTEM ECONOMICS

1.	NET ANNUAL BENEFIT OF SOLAR SYSTEM (B3-A10)	$ - 313
2.	FIXED COST TO SAVINGS RATIO; TOTAL INSTALLED COST/NET ANNUAL BENEFITS (E, App.D, Exhibit 2 ÷ C1)	Negative number. $ See note below.

Note: December 1977 fuel rates produce this negative result. With a 15% yearly increase in gas/oil prices, next year's solar benefit (C1) will be +$764 and the fixed cost to savings ratio (C2) will be +$846.

System start-up is expected in early 1981.

*Based on December 1977 Rates

Solar Energy Products, Inc.

Supplier of Solar Energy Equipment

QUOTATION

O: Airports Commission of City and County of San Francisco
San Francisco International Airport
San Francisco, CA 94128

DATE: January 27, 1978
PROJECT NAME: San Francisco
PROJECT ADDRESS: San Francisco
PROJECT NUMBER: 181.1.S
S.E.P. FILE NO.: 1056

QUANTITY	PART #	ITEM	UNIT PRICE	TOTAL
240	CU30-WW	Flat plate solar collector panel with water white glass cover plate	$325.00	$78,000.00
		Shipping		4,300.00
		Total (FOB San Francisco, CA)		$82,300.00

Time Period: This quotation is good for 180 days from January 31, 1978.

Standards Compliance: The above quoted items comply with the specific provisions of the HUD Intermediate Minimum Property Standards Supplement, HUD Document 4930.2, 1977 Edition, Solar Heating and Domestic Hot Water Systems, Volume 5.

ELIVERY: 60 days

O.B.: San Francisco, CA

SUBMITTED BY: Jay C. McLaughlin
SOLAR ENERGY PRODUCTS, INC.

ERMS: Prepaid, C.O.D. or net 30 days with approved credit.

his quotation is subject to all of the terms and conditions on the reverse side hereof, and to all properly executed agreements between the parties.

CF-577-11

TERMS AND CONDITIONS OF SALE

PRICES: Subject to change without prior notice.

FREIGHT: All orders are shipped F.O.B. our factory.

CRATING/ PACKAGING: The cost of standard packaging is listed on our price list. The prices shown do not include any special crating or packaging charges for shipments outside of the continental U.S.A. The cost of special packaging as required by Buyer or required by U.S. regulation shall be borne by Buyer.

TITLE AND RISK OF LOSS: Title and risk of loss shall pass to Buyer on delivery of goods, to a carrier selected by Seller or a carrier requested by Buyer. Buyer shall accept and inspect all shipments immediately upon arrival and shall file claims with or against the carrier for any losses, shortages, or damages of any kind. All claims, including shortages, must be filed in writing within 10 days after receipt of goods.

DELAYS: Specified delivery dates are subject to availability of material and labor. Seller shall not be liable for, and at its election, shall be excused from performance of orders if its failure to perform is due to fire, flood, acts of God, explosion, labor difficulties, mechanical breakdown, accidents, prior commitments, priority of Government orders, or any other cause beyond Seller's control. Any such reasons for delay shall extend the time for performance of the order by the number of days required to correct the cause of delay.

RETURNS: Material made to order is not returnable. Stock material is only returnable when permission has been granted by Solar Energy Products, Inc., and is subject to handling and refinishing charges (minimum 10%). Shipping charges on all return goods must be prepaid. We require invoice number and date of sale with returned goods, and permission for return must be requested in writing within 30 days after receipt of merchandise.

POLICY: Solar Energy Products, Inc. reserves the right in its sole discretion, to refuse acceptance of any order, from any source, at any time. Quotations are valid for a period of thirty (30) days from date of issue; orders based on quotations which are more than thirty (30) days old shall not be accepted unless and until the original quotation is confirmed by Solar Energy Products, Inc. The only warranty, guaranty or representation by Solar Energy Products, Inc. in connection with this sale and purchase is as appears in the Company's published product warranty.

TERMS: All orders are to be prepaid or shipped COD unless otherwise specified. In the event that Solar Energy Products, Inc. takes any action to enforce its legal rights in connection with any sale and purchase, or to collect any sums due therefrom, the Buyer shall pay all cost of any such action, including, but not limited to, a reasonable attorney's fee and costs, and a reasonable attorney's fee and costs on appeal.